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JOHN M. CLARKE Director

Bulletin 100

ECONOMIC GEOLOGY 14

FIRE TESTS

OF

SOME NEW YORK BUILDING STONES

BY

W. E. McCOURT

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New York State Education Department

Science Division, Sep. 26, 1905

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Commissioner of Education

SIR: I beg to communicate for publication as a bulletin of the State Museum a treatise on *Fire Tests of New York Building Stones*, prepared by W. E. McCourt. The usefulness of this treatise to engineers, architects and boards of underwriters will, I believe, be immediate.

Very respectfully yours

JOHN M. CLARKE

Director and State Geologist

Approved for publication, Sep. 26, 1905

A. S. Draper

Commissioner of Education

New York State Education Department

New York State Museum

JOHN M. CLARKE Director

Bulletin 100

ECONOMIC GEOLOGY 14

FIRE TESTS

OF

SOME NEW YORK BUILDING STONES

BY

W. E. McCOURT

INTRODUCTORY NOTE

The recent extensive conflagrations in some of our large cities have made more urgent than ever a demand for definite knowledge of the capacity of various construction stones for resistance to fire. Little has been done in the investigation of refractoriness of building stones and it is probable that the occasional recorded tests have been based on series too incomplete and on samples too small for reliable coordination of results.

With the purpose of acquiring some definite information regarding the fire-resisting qualities of certain New York building stones, Prof. Heinrich Ries has, at my request, initiated and superintended the investigation here given, the details of the work having been carried out by Mr W. E. McCourt.

The types of building stones on which the work is based have been selected as representative of those produced in this State and all have been assembled specially for these investigations. A few examples also have been tested which are not now used for structural purposes.

The work has been done carefully and thoroughly and the result arrived at should prove of value to engineers, architects and fire insurance underwriters.

JOHN M. CLARKE
State Geologist

FIRE TESTS OF SOME NEW YORK BUILDING STONES

To determine the durability and desirability of the various building stones they are subjected to a number of artificial tests. The agents at work tending to destroy the building stone are the crushing and shearing forces caused by its position in a structure, the chemical action of gases and moisture in the atmosphere, and the physical agencies due to changes of temperature. The determinations sought in the laboratory of the effects of these various agencies are by tests for: crushing and transverse strength, permanence of color, specific gravity and weight per cubic foot, porosity and percentage of absorption, effect of alternate freezing and thawing, effect of the action of gases, as CO_2 and SO_3, effect of alternate expansion and contraction and effect of extreme heat.

It is our purpose to discuss the relative effect of extreme heat on a series of typical New York building stones. This phase of testing building stones has been heretofore more or less overlooked, yet its importance is evident so long as building construction in centers of population is largely dependent on these materials. A knowledge of the relative effect of extreme heat on the various stones employed for building purposes is of value in determining the kind of stone to be used in constructions and locations exposed to the chance of conflagration.

PREVIOUS INVESTIGATIONS OF THE REFRACTORINESS OF BUILDING STONES

The first investigator to carry on any series of tests to ascertain the relative capacity of the various building stones to resist the action of extreme heat was Cutting, who performed some experiments for the *Weekly Underwriter* in order that insurance rates might be more properly adjusted. He estimated the relative rank of different stones in their capacity to withstand the action of extreme heat as, from highest to lowest, marble, limestone, sandstone, granite and conglomerate.

Cutting[1] states:

As to granites . . . a heat sufficient to melt lead is sufficient to injure granite walls beyond the capability of repair, otherwise than by taking down, and it is almost, if not quite, impossible to burn out a granite building of small size, even, without injuring the walls.

Sandstones stand fire much better than granite. They stand uninjured a degree of heat that would destroy granite.

[1] Weekly Underwriter. 1880. 23:42.

Limestones and marble stand close up to and in some instances exceed the value of freestones.

The conglomerates and slates show no capacity to standing heat, as the slates crack and conglomerates are almost immediately ruined.

With regard to the granites, Cutting[1] further states:

All these samples of building stones have stood heat without damage up to 500°C.[2] At 600° a few are injured, but the injury in many cases commences at or near that point. When cooled without immersion, they appear to the eye to be injured less but are ready to crumble and I think they are many times nearly as much impaired, and always somewhat injured, where water produces any serious injury.

As to the sandstones, he continues:

While as a whole they stand both heat and water better than granite, they are more or less injured. In fine, the capability of resisting heat has little connection with their density.

Of limestones, he says:

Limestones and marbles have come through the fiery ordeal more favorably than any of the other stones . . . The limestones and marbles seldom crack from heat and water. But when heat from the outside is excessive, they slightly crumble on the outside if water is thrown on them. When they are cooled without the application of water, the injury is much less.

The specimens tested stood fire well, as a whole, up to the temperature of heat necessary to convert them into quicklime, and at such a heat, if long continued, they are changed so as to flake off and crumble down. In most cases this heat is greater than 900°F. and in some cases beyond 1000°F.

N. H. Winchell[3] has carried on a series of experiments on the building stones of Minnesota. He made use of a muffle furnace in which the temperature was raised to a red heat. One and one half to two inch cubes were placed in the furnace, and during heating were removed once or twice so that the effects of the treatment might be observed. The samples were then removed from the furnace and while hot were immersed in a tank of water and the results again noted. A study of the tables of that report shows that most of the stones cracked more or less. The effect of the sudden cooling of the stone was more disastrous than the mere heating.

Buckley[4] in his experiments on the building stones of Wisconsin used 1 and 2 inch cubes in a muffle furnace in which the temperature was gradually increased from 600° to 1500° F. The effect of heating was noted from time to time. At 1300° to 1500°

[1] *Idem.* 1880. 22:257, 287, 304.
[2] The author here refers to the centigrade scale.
[3] Minn. Geol. & Nat. Hist. Sur. Final Rep't. 1884. 1:186.
[4] Wis. Geol. & Nat. Hist. Sur. Bul. 1898. 4:73.

the samples were taken out; most of them were allowed to cool slowly and some were cooled suddenly by being plunged into cold water. He states:

Different building stones show a considerable difference in the capacity which they have to withstand high temperatures. Other things being equal, it appears that a rock having a uniform texture and a simple mineralogical composition has the greatest capacity to withstand extreme heat. It is known that rocks are poor conductors of heat, and for this reason the outer shell of a rock may be very highly heated while the interior remains comparatively cold. If, after heating, the rock be quickly cooled, contraction of the outer shell takes place. The differential stresses occasioned thereby ruptures the rock and the outer shell is thrown off.

Buckley[1] continues:

As a result of the experiments . . . it was discovered that all the samples, when struck by the hammer or scratched with a nail, after being taken from the muffle furnace, emitted a sound similar to that which would be given off by a brick. This sound was characteristic not only of the sandstones, but also of the granites and some of the limestones.

The planes of lamination of the originally stratified samples were brought out more distinctly as the temperature was increased. But few of the limestone samples, which were tested in the muffle furnace, were injured by gradual heating and cooling, except when the temperature reached a point where calcination occurred. This temperature was generally from 1000° to 1200°F. When the limestone samples were suddenly cooled they always flaked off at the corners.

The very coarse grained granite broke into a great many pieces, and may be said to have exploded. The cracks were so numerous that the stone was broken into fragments not much larger than the individual grains. The medium grained granite . . . developed cracks through the middle of the sample.

In contrast with the limestone and granite samples, the sandstones were, to all outward appearances, little injured by the extreme heat. The samples which were taken from the muffle furnace and allowed to cool gradually were apparently as perfect as when first placed in the furnace. But after they had cooled, one could crumble any of them in the hand, almost as readily as the softest incoherent sandstone. In fact, when they were heated to a temperature of 1500°F. some of the samples had become so incoherent that it was barely possible to pick them up after cooling, without their falling to pieces.

G. P. Merrill[2] summarizes the effect of heat on stones as follows:

The injurious effects of artificial heat, such as is produced by a burning building, are, of course, greater in proportion as the temperature is higher. Unfortunately, sufficient and reliable data are

[1] *Idem.* 1898. 4:385.
[2] Stones for Building and Decoration. N.Y. 1903. p. 424.

not at hand for estimating accurately the comparative enduring powers of stone under these trying circumstances. It seems, however, to be well proven that of all stones granite is the least fireproof, while the fact that certain of the fine grained silicious sandstones are used for furnace backings would seem to show that if not absolutely fireproof, they are very nearly so.

It must be remembered, however, that the sudden cooling of the surface of a heated stone, caused by repeated dashes of cold water, has often more to do with the disintegration than heat alone.

In his report on the building stones of Missouri, Buckley[1] says:

In the case of limestone or dolomite the effect of gradual heating will be manifest by calcination, while sudden cooling will result in the flaking off of the corners. Sandstone and granite may show very little outward appearance of injury, although their strength may be so affected, especially in the case of sandstone, as to permit of their being crumbled in the hand. When suddenly cooled, ordinary sandstone shows very little exterior evidence of injury, while granite may show cracks without flaking. Stone which has been heated to a high temperature emits a characteristic ring when struck with metal. When scratched it emits a sound similar to that of a soft burned brick. This may be due to the loss of water of composition by the minerals composing the rock.

Experiments which have thus far been performed seem to indicate that few, if any, stones will withstand uninjured a temperature of 1500°F.

Van Schwartz[2] performed a series of tests on building stone and arrived at the conclusion that granite is of little account as a fireproof building material, and "neither sandstone nor limestone can be classed as flameproof, not to say fireproof, or is capable of affording any protection whatever in case of fire, since the former cracks at red heat and the latter is converted into quicklime at from 600° to 800°C."

EFFECT OF FIRE ON STONE AS OBSERVED IN CONFLAGRATIONS

From time to time extensive conflagrations have swept over cities, resulting not only in the destruction of millions of dollars worth of property, but also in the loss of life. Within the past few years the fires at Rochester in 1904, Baltimore in 1904 and Paterson in 1902, have given us an opportunity to study, in a general way, the effect of extreme heat on the various kinds of stone used for building purposes. However, it is not safe to draw any very definite conclusions from such observations, for the conditions and influences to which the stones were subjected may have differed very considerably in different parts of the burned area,

[1] Mo. Bur. Geol. & Mines. Ser. 2. 1904. 2:50.
[2] Fire and Explosion Risks; a Handbook for the Investigation and Prevention of Fires and Explosions. Trans. by Salter, London. 1904. p. 66.

and moreover, there was, at the time, no thought of a means of making accurate observations of the conditions existing while the fire was in progress. The temperature may, in a general way, be estimated from the effect upon various metals in the fire; yet, withal, the conditions might vary so considerably as not to allow of any general conclusions. The fact that iron was melted at one point does not prove the existence of a similar temperature 50 feet away.

Many of the reports which have been circulated relative to the degree of heat attained in a fire are decidedly exaggerated, but experts are of the opinion that the heat seldom reaches a temperature greater than 1800°F, and usually it is much less.

But one conclusion can be reached after a study of the effect of fires on stone and that is that no building stone is absolutely fireproof, although some stones, in a way, show much more refractoriness than others. It must be granted, however, that some of the reports are rather overstated. For example, one writer[1] says:

The results of the various fires have proved the unreliability of granite and stone; the granite buildings were reduced to sand. Granite not only splits under heat, but from unequal expansion of the constituents, as it is porous and contains water in hygroscopic form, the steam generated by the heat bursts the rocky constituents into small particles. By these several actions the material is perfectly disintegrated. We all know that marble, as a limestone, is even more liable to speedy calcination, that sandstones vary much in density, their particles expand unequally and some split or crumble into pieces. The Baltimore conflagration has at least proved the worthlessness of natural stone to resist great heat, and for staircases in public buildings both lime and sandstone have long been held to be exceedingly dangerous under the action of fire and water.

Another observer[2] says:

To many persons the Baltimore fire seems to have put the question whether the American city of today can be so builded as to be safe from such fires as those at Chicago in 1871, and at Boston in 1873, and to have answered it in the negative. The 150 acres of black and smoking ruins which were once the most substantially built portion of the sixth city of the United States permits no other conclusion. Already, on this showing alone, the public press has widely condemned the modern type of fireproof building, and some even whose words were weighted with expert authority in the public mind, have called for a return to "brick and mortar" as the only salvation of the building owner when conflagration besets his property.

[1] Lessons from the Baltimore Fire. Building News and Engineering Jour. 1904. 87:2.
[2] Engineering News. 1904. 51:173.

This same writer observed that the window seats, lintels, projecting cornices and, in short, all exposed corners in thin edges of stone work were badly broken and splintered.

With regard to the effect of the Baltimore fire on stone work Grieshaber[1] says:

Stone generally acted badly. Granite, especially the Maryland, spalled and cracked even where heat did not seem to be great. Marble calcined, and in some places seemed to be consumed with the heat. Limestone and buff sandstone acted badly and the only brownstone that seemed to stand heat fairly well was a dark brown of the appearance of Connecticut or Belleville. Slate generally acted badly. It shivered into splinters.

Woolson[2] in a report to the *Engineering News* says of the effect of the fire at Baltimore on building stones:

All varieties of natural stone suffered severely from the fire. Granite, sandstone, limestone, marble and slate all perished before the long continued high temperature. Granite and sandstone cracked and spalled, limestone and marble cracked and calcined, while the slate shivered into thousands of thin plates.

There are some interesting exceptions to this general rule, whether due to the variety of the stone or the way the heat struck it, I am unable to state positively, but the former appeared to be the controlling cause.

Maryland granite, such as used in the Maryland Trust building and the Custom House failed badly. The same was true of the granite in the Baltimore & Ohio Railroad Co.'s building, which was said to come from Missouri. On the other hand, the Milford granite in the Equitable was little damaged, and that in the Calvert building (which looks like a New England stone) is in fair condition. The most remarkable preservation of granite I noticed was in the polished front of the First National Bank. It is in perfect condition, despite the fact that nothing but the walls remain.

Sandstone should give the best record of any of the stones, but in most cases it seemed to have succumbed like the others. Lake Superior red sandstone seems to be the stone employed in the Farmers and Merchants National Bank. It was badly spalled. Brown sandstone gave an equally poor showing in numerous buildings, but I noticed the front of three buildings which were in remarkable contrast, for they were uninjured. . . Two of these buildings had wooden interior construction and were completely burned out, as well as all the surrounding buildings, but the face walls withstood the heat without any apparent damage, while the huge granite blocks of the Custom House a few doors away were ruined.

Plates 1-8 show the effect of fire on building stone. The Pater-

[1] *Idem.* 1904. 51:173.
[2] *Ibid.* 1904. 51:95.

son views were taken from a pamphlet issued by the Continental Insurance Co. of New York on *The Conflagration at Paterson N. J.* The Baltimore views were taken from the report of the committee on fire resistive construction of the National Fire Protection Association of Chicago, issued in 1904, and from a pamphlet of the Mississippi Wire Glass Co. of New York entitled *A Reconnaissance of the Baltimore and Rochester Fire Districts.* The Rochester view was also taken from this last source.

TESTS MADE ON NEW YORK BUILDING STONES

Eighteen samples of New York building stones were selected for testing. The list of these is given below.

Plate 1

Fig. 1 Showing damage to granite in the City Hall at Paterson N. J. 1902

Fig. 2 Ruins of the Danforth City Library at Paterson N. J. 1902

Plate 2

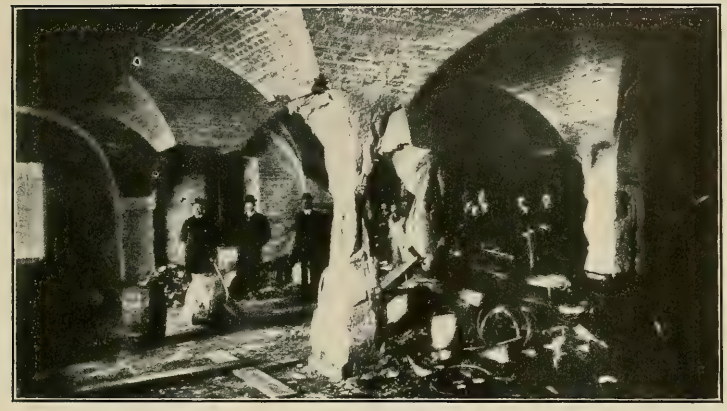


Fig. 1 Showing damage to granite pillars in United States Public Store House No. 1 at Baltimore Md. 1904

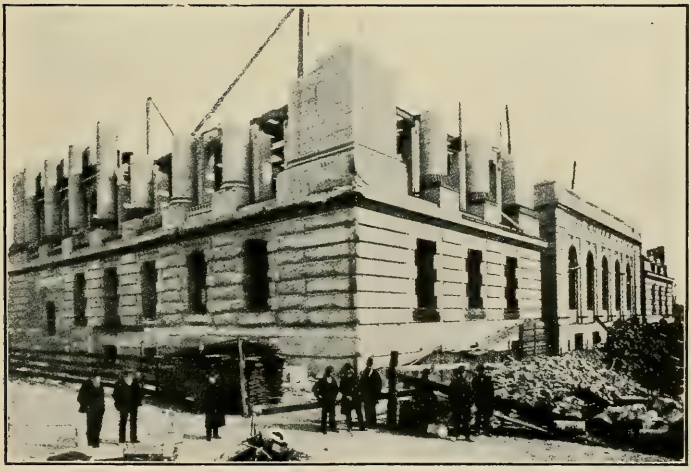
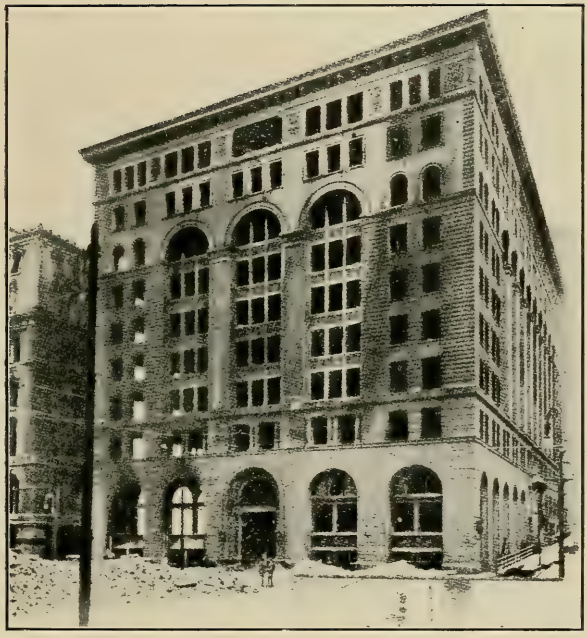


Fig. 2 Showing effect of the fire on granite in United States Custom House, Baltimore Md. 1904

Plate 3



Equitable Building, Baltimore Md. The granite in this building was little damaged by the fire. 1904

Plate 4

Sandstone front of the Maryland Trust Building at Baltimore Md., damaged by the fire. 1904

Fig. 1 Bluestone front of the Baltimore & Ohio Railroad Co.'s building at Baltimore Md., damaged by fire. 1904

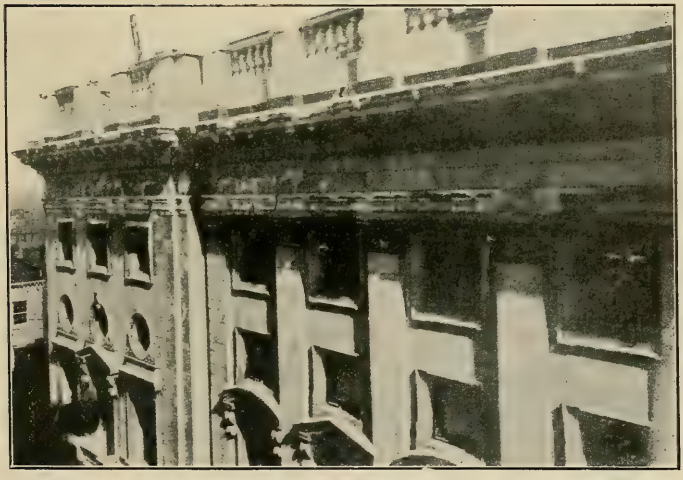
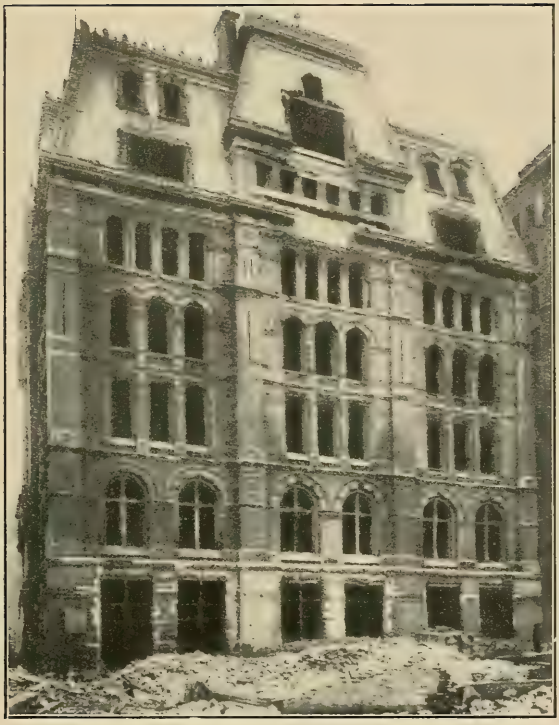


Fig. 2 City Courthouse at Baltimore Md., showing the damage to the marble facing. 1904

Plate 6



Baltimore & Ohio Railroad Co.'s building at Baltimore Md., showing the effect of the fire on the stonework and the slate roof. 1904

Fig. 1 Commercial & Farmers National Bank building at Baltimore Md., showing the damage to the stone carving. 1904

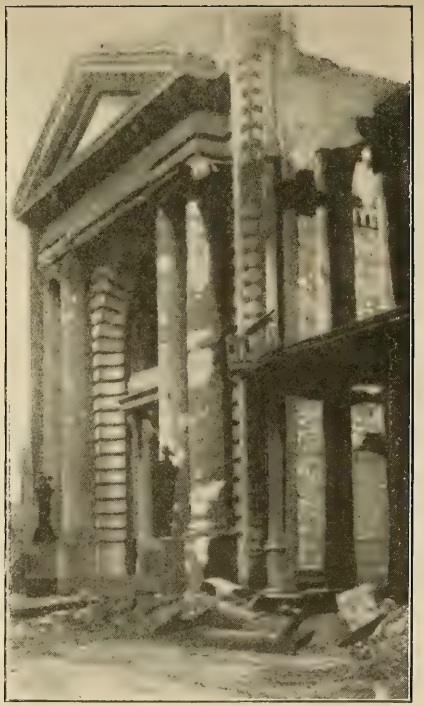
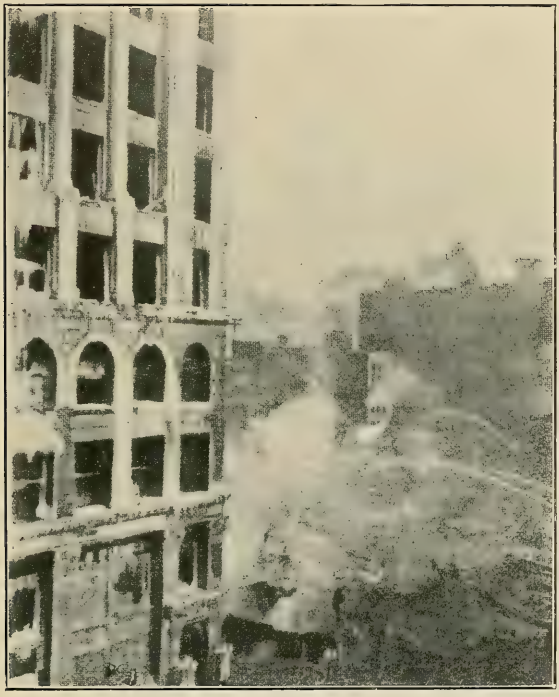


Fig. 2 Marble front of building of the International Trust Co. of Maryland, Baltimore Md., damaged by the fire. 1904

Plate 8



View of the burned district at Rochester N. Y. 1904

Tables showing the locality number, locality, company operating the quarry, use, general description and percentage of absorption of the stones tested in the laboratory.

TABLE 1[1]

Granites and gneisses

LOC. NO.	LOCALITY	COMPANY	DESCRIPTION OF STONE	USE	PER CENT ABSORPTION
1	Pine Island, Orange co.	Empire State Granite Co.	Granite, coarse grained, pink	Building stone, paving block	.192
2	Garrison, 2½ m. s., Putnam co.	King Granite Co.	Granite, fine grained, gray	Building stone, paving block	.289
3	Peekskill, 3 m. s. e., Westchester co.	Coleman, Bruchard & Coleman	Granite, medium grained, light gray	Used only in construction of Croton dam	.291
4	Nyack, 2 m. n., Rockland co.	Manhattan Trap Rock Co.	Diabase, fine grained, dark gray	Road metal, concrete	.222
7	Keeseville, 2½ m. s., Essex co.	Property of C. B. White	Norite, medium grained, greenish	Building stone (not worked)	.188
9	Grindstone island, Jefferson co.	Parry Bros.	Granite, fine grained, red	Paving block	.178
10	Grindstone island, Jefferson co.	Kelly & Packard	Granite, coarse grained, red	Building and monumental stone	.155
11	Little Falls, Herkimer co.	Halliman Bros.	Augen gneiss, greenish gray	Road metal, some construction work	.304
14	Northville, 1. m. n., Fulton co.	Northville Granite and Marble Co.	Granite, coarse grained, dark gray	Monumental stone(not worked)	.107

[1]Other igneous rocks besides granite are included in this table.

TABLE 2

Sandstones

LOC. NO.	LOCALITY	COMPANY	DESCRIPTION OF STONE	USE	PER CENT ABSORPTION
8	Potsdam, 3 m. s., St Lawrence co.	Potsdam Red Sandstone Co.	Red, quartzitic, fine grained, compact	Used extensively as a building stone	2.31
16	Oxford, Chenango co.	F. G. Clarke Bluestone Co.	Blue to gray, fine grained	Building stone	1.188
17	Medina, Orleans co.	Carson Bros.	Red, fine grained, somewhat quartzitic	Widely used for building purposes	1.876
19	Warsaw, Wyoming co.	Warsaw Bluestone co.	Blue to gray, very fine grained	Building stone	3.084

TABLE 3

Limestones

LOC. NO.	LOCALITY	COMPANY	DESCRIPTION OF STONE	USE	PER CENT ABSORPTION
5	Sandy Hill, ½ m. n., Washington co.	Higley & Barber	Fine grained, blue gray, compact	Flagging and structural work	.063
12	Little Falls, Herkimer co.	P. Kearney	Light gray, dolomitic and silicious	Used locally as a building stone	1.399
13	Palatine Bridge, ¾ m. w., Montgomery co.	Mohawk Stone Co.	Variable, gray to black, compact to earthy	Formerly as a building stone, now quarried for railroad ballast	.057
15	Amsterdam, 1 m. n. e., Montgomery co.	D. C. Hewitt	Fine grained, gray, compact	Structural work, lime, road metal	.05

TABLE 4

Marble

LOC. NO.	LOCALITY	COMPANY	DESCRIPTION OF STONE	USE	PER CENT ABSORPTION
35	Gouverneur, St Lawrence co.	St Lawrence Marble Co.	Blue to gray, fairly coarse	Building and decorative stone	.142

DESCRIPTION OF FIRE TESTS

The samples from each locality were cut into three inch cubes. Most investigators, who have studied the refractoriness of building stones, have selected one or two inch cubes; but these sizes do not give as accurate results as the larger ones, for the reason that a small piece becomes easily heated throughout the mass and consequently upon neither heating nor cooling are differential stresses between the interior or exterior likely to be set up, as would be the case if larger cubes are selected. In actual fact in the burning of a building the stone does not become thoroughly heated; the heat penetrates probably but a slight distance into the mass, while the interior may remain comparatively cold. The heating and cooling of this outer shell causes strains which do not obtain in a stone which has been heated throughout its entire body. One, two and three inch cubes of the same kind of stone have been tested in the laboratory and while the smaller cubes stood fire very well, the larger ones were more affected and in some cases went to pieces. It was to avoid this error and to approach more closely the existing conditions in a conflagration that the three inch samples have been employed in the present series of tests.

As far as the number of cubes would admit six tests were made on the stone from each locality, four furnace and two flame tests, For the first set of experiments a Seger gas furnace was used. thus allowing the cube to be gradually and evenly heated. An opening was cut in the cover of the furnace large enough to admit the three inch cube of stone, to which a wire had been attached to facilitate its handling.

One sample was heated at a time. The heat was applied gradually for half an hour until a temperature of 550°C. was reached, which was maintained for half an hour. The temperature was measured with a thermo-electric pyrometer. The cube was then taken out and allowed to cool in the air. A second sample was heated, as before, to 550°, and this was suddenly cooled by a strong stream of water. The third and fourth cubes were heated to 850°C. kept at that temperature for half an hour and cooled slowly and suddenly as in the 550° tests.

In order to approach more nearly the conflagration conditions samples were subjected to two flame tests. In the first case the cube was so placed as to be enveloped on three sides by a steady but not strong gas blast. The flame was allowed to play on the cube for 10 minutes, then the samples were allowed to cool for

five minutes after which time the flame was again applied for 10 minutes and the cube was again allowed to cool. To determine the combined action of heat and water a second cube was subjected, as before, to the flame for 10 minutes, then a strong stream of water was turned on to the sample, along with the flame, for five minutes. Then the water was turned off and the flame continued for another five minutes, after which, for five minutes more the flame and water together were allowed to act on the sample.

The results of these various tests are given in the sections of the paper which follow and the tabulated effects are shown in tables 5, 6, 7 and 8 with the separate sections. Reference to the plates will show plainly the effect of these experiments on the different kinds of stone.

Thin sections of most of the rocks tested were examined under the microscope with the hope that they might shed some light on the cause of the variations in refractoriness of the different stones. Unfortunately they did not and therefore the petrographic descriptions are placed at the end of the paper.

Fire tests on granites and gneisses

The cubes, for the most part, in the 550° tests stood up very well. All of the samples remained uninjured on slow cooling, with the exception of the gneiss from Little Falls (11)[1] which developed a few cracks. On sudden cooling but two samples seemed to have been injured, and only slightly so. These are a coarse grained granite from Pine Island (1) and a fine grained granite from Grindstone island (9). The gneiss from Little Falls (11) was measurably more affected on fast than on slow cooling. It will be noticed in reference to the table that three of the samples, Pine Island (1), Little Falls (11) and Northville (14), took on a brownish tinge. This is probably due to a change in the condition of the iron present from a ferrous to a ferric state.

At the higher temperature (850°) none of the samples remained uninjured, though some suffered more than others. In all cases the sudden cooling did more damage than the slow cooling. The gneiss, Little Falls (11), acted very badly, especially on sudden cooling, in which test it split parallel to the bands and had numerous other cracks. The fine grained stones, Nyack (4) and Grindstone island (9), showed a tendency to spall off at the corners, while all the other samples, which are coarse grained, cracked very

[1]These numbers refer to samples as listed and described at the end of the paper.

irregularly, usually around the individual grains. In the Peekskill sample (3) this cracking went so far as to cause the stone to be broken into fragments the size of the mineral particles making up the rock. The very coarse sample from Northville (14) suffered badly.

In the flame test one of the cubes, Nyack (4) remained intact and most of the others were but slightly injured. The fine grained granite from Grindstone Island (9) was the most visibly affected, having a large piece broken off from the corner against which the flame was directed. The gneiss, Little Falls (11), besides having a small corner broken off developed some cracks parallel to the banding.

Under the action of the flame and water none of the cubes remained uninjured, though in the Keeseville (7) and Northville (14) samples only small cracks were developed. The Pine Island granite (1) was badly cracked, yet only a few grains came off the edge. The Peekskill granite (3) was disintegrated, breaking up into its individual grains and the Little Falls gneiss (11) was very badly affected. The samples from Garrison (2), Nyack (4) and Grindstone island (9) were quite badly injured, while the coarse grained Grindstone island stone (10) was less affected.

TABLE 5

Fire tests on granites and gneisses

LOC. NO.	LOCALITY	550° SLOW COOLING	550° FAST COOLING	850° SLOW COOLING	850° FAST COOLING	FLAME TEST	FLAME AND WATER TEST
1	Pine Island, Orange co.	82 Slight brown tinge, otherwise unchanged	83 Slight brown tinge, one small crack on one side	81 Slight brown tinge, some irregular cracks	No cube tested	156 Slight crack across upper face, some grains off edge	122 Corner badly cracked, some grains off
2	Garrisons, Putnam co.	90 Unchanged	01 Unchanged	No cube tested	No cube tested	157 Small piece off corner, slight crack across corner	123 Large piece off front edge, some small pieces and grains
3	Peekskill, Westchester co.	112 Unchanged	113 Unchanged	114 Badly cracked, especially across the corners	115 Badly effected, went to pieces in fragments the size of the grains	158 Small corner off in small pieces, two slight cracks	124 Badly affected, went to pieces
4	Nyack, Rockland co.	116 Unchanged	117 Unchanged	118 Brown tinge, one crack around three sides	119 Brown tinge, one bad crack around three sides, three corners cracked, other small cracks	159 Unchanged	125 Cube split in two other cracks, front edge off in several pieces
7	Keeseville, Essex co.	120 Browned, otherwise unaffected	121 Browned, otherwise unaffected	No cube tested	No cube tested	No cube tested	127 One slight crack at edge and corner
9	Grindstone island, Jefferson co.	30 Unchanged	31 Few small cracks	32 Some cracks, across the corners	33 Some cracks, also cracked across the corners	162 Three inch corner off in one small and one large piece	129 Badly affected, cube split in two, many smaller pieces
10	Grindstone island, Jefferson co.	43 Unchanged	44 Unchanged	45 Badly cracked irregularly	42 Very badly cracked, irregularly	163 Small piece off corner	130 More affected than 163, several pieces and grains off
11	Little Falls, Herkimer co.	95 Slight brown tinge, few cracks	96 Slight brown tinge, one crack almost around four sides parallel to banding, one smaller crack	107 Browned, one open crack around three sides along banding, one across banding	97 Browned, badly cracked, split in two along banding, one large piece off	164 Some cracks, small piece off corner	131 Quite badly affected, cracked considerably, many pieces off front edge
14	Northville, Fulton co.	104 Brown tinge, otherwise unaffected	105 Brown tinge, otherwise unaffected	No cube tested	106 Badly cracked, grains off, one corner almost off	167 Two slight cracks	134 Two slight cracks

Fire tests on sandstones

After having been heated to 550° none of the samples remained uninjured, though in all cases, on slow cooling, the cracks which developed were very slight and along the bed. The Warsaw bluestone (19) was changed to a deep brown color and besides cracking slightly along the bed, also showed some small transverse cracks. The Oxford sandstone (16) also took on a brown tinge because of the change in the condition of the iron present in the stone. The sudden cooling damaged the stones to a slightly greater extent. The Medina sandstone (17) seems to have suffered the most, for it not only developed cracks along the bed, but split in two and showed some transverse cracks.

In the 850° tests all of the cubes except the Warsaw bluestone (19) split in two along the bed, both after slow and sudden cooling, and in all cases, except in the sample from Warsaw, slight transverse cracks were developed. The Warsaw stone was not very badly affected on slow cooling, but upon fast cooling developed one open crack around three sides, along the bed. The lamination planes of the Potsdam stone (8) were made more prominent as the heat was increased.

Under the action of the flame, but one sample, Oxford (16), came through without losing a piece from the corner, but around the corner were two series of cracks. The sandstones from Medina (17) and Warsaw (19) had small pieces broken off, while the Potsdam sample lost a large piece. In no cases were any cracks developed along the bed.

Under the action of the flame and water the cubes all suffered the loss of the corners. The Warsaw sample (19) was split into eight parallel plates. The Potsdam cube (8), besides being badly broken at the corner, split in two along the bed. The Oxford stone (16) lost a large part from the corner and upper edge and the sample from Medina (17) lost a small portion from an upper edge, but developed a crack around three sides and along the bed.

TABLE 6

Fire tests on sandstones

LOC. NO.	LOCALITY	550° SLOW COOLING	550° FAST COOLING	850° SLOW COOLING	850° FAST COOLING	FLAME TEST	FLAME AND WATER TEST
8	Potsdam, St Lawrence co.	61 One slight crack along bed	62 Bedding planes more prominent, two slight cracks along bed	60 Bedding planes more prominent, cube split in two along bed, two small transverse cracks	63 Bedding planes more prominent, cube split in two along bed, some transverse cracks, one spall	161 Some small cracks, two inch piece off corner	128 Cube split in two along bed, corner and edges badly broken, many pieces off
16	Oxford, Chenango co.	11 Brown tinge, some slight cracks	12 Brown tinge, some slight cracks	9 Brown tinge, cube split in two along bed, some transverse cracks	10 Brown tinge, cube split in two along bed	168 Two series of parallel cracks around corner, no pieces off	136 Large piece off corner and edge in several fragments
17	Medina, Orleans co.	14 Few slight cracks along bed	13 Color slightly darker, cube split in two along bed, other cracks along bed, some across	16 Color slightly darker, cube split in two along bed, other cracks	15 Color slightly darker, cube split in two along bed, other cracks along bed, some across	169 Two small cracks, small piece off corner	137 Cracked along bed around three sides, corner and upper edge off in several pieces
19	Warsaw, Wyoming co.	2 Browned, few slight cracks along bed, some small ones transverse	1 Browned, some cracks along bed, small transverse ones on three sides	4 Deep brown, not badly cracked	3 Deep brown, one prominent crack around three sides approximately along bed	171 Small piece off corner	139 Badly affected, cube split into 8 parallel layers

Fire tests on limestones

As a whole, the limestones may be said to have been little affected at the low temperature after slow cooling. Nor has calcination taken place at 550°. The sample from Palatine Bridge (13) developed one slight crack around the cube, but the others remained intact. On sudden cooling, the Sandy Hill (5) and Little Falls (12) samples still remained unchanged, but the Amsterdam cube (15) showed one irregular crack around four sides, and the cube from Palatine Bridge (13) was slightly more damaged than the slowly cooled cube.

At 850° all the samples were calcined to a greater or less extent; due to the varying compositions of the stones. The Little Falls sample (12) showed only slight calcination because it is very dolomitic and contains much silica. Likewise the cube from Sandy Hill (5) because of its silicious nature, showed little calcination, while the Palatine Bridge stone (13) flaked off considerably. Upon slow cooling the Little Falls sample (12) developed one small crack around two sides, while the Palatine Bridge cube (13) flaked off badly and showed some cracks. After sudden cooling the Little Falls stone still continued to stand up very well, showing but two slight cracks. The Sandy Hill cube (5) developed one open crack on one side, and the Palatine Bridge stone (13) showed one open crack around three sides besides some transverse ones. In the slowly cooled cube the quicklime flaked off, but in the suddenly cooled one it did not flake. This is due, probably, to the "setting" of the quicklime when the water was applied.

The sample from Little Falls (12) was the only one to lose a piece from the corner in the flame tests. The others were slightly cracked but lost no pieces from the corners. In all cases, however, the action of the flame and water damaged the corners to the extent that pieces came off. The sample from Little Falls (12) lost a large piece and the Sandy Hill (5) and Amsterdam (15) stones lost smaller pieces, while the cube from Palatine Bridge (13) was quite badly injured.

TABLE 7

Fire tests on limestones

LOC. NO.	LOCALITY	550° SLOW COOLING	550° FAST COOLING	850° SLOW COOLING	850° FAST COOLING	FLAME TEST	FLAME AND WATER TEST
5	Sandy Hill, Washington co.	92 Unchanged	93 Unchanged	No cube tested	94 Calcined, no flaking, one open crack on one side	160 Cracked at front edge, no pieces off	126 Small pieces off corner
12	Little Falls, Herkimer co.	38 Unchanged	39 Unchanged	40 Slight calcination, one small crack around two sides	41 Slight calcination, two small cracks	165 Two inch piece off corner	132 One small crack, large piece off corner and front edge
13	Palatine Bridge, Montgomery co.	54 One slight crack around the cube	55 One crack around the cube	56 Calcined, flaking off of quicklime, some cracks	57 Calcined, flaking not so bad as in 56. One open crack around three sides, some smaller ones	166 One slight crack at front edge	133 Large front edge off in several pieces, little pieces calcined
15	Amsterdam, Montgomery co.	88 Unchanged	89 One irregular crack around four sides	No cube tested	No cube tested	No cube tested	135 Some small pieces off corner, little pieces calcined

Fire tests on marble

Only one sample of marble was tested, Gouverneur (35). The stone was little affected at the lower temperature, only in the suddenly cooled cube did any cracks appear and here they were but slight and seemed to be along planes of weakness due to the difference in texture of parts of the stone.

At the higher temperature the slowly cooled cube was disintegrated to a greater extent than the fast cooled sample. The former made a poor showing and had one bad crack around three sides while the latter shows no cracks and the corners were but slightly rounded. The greater disintegration of the slowly cooled cube is due, as in the limestones, to the "setting" of the lime under the action of the water.

The flame alone cracked the sample badly and caused some small pieces to be broken off from the edge. The flame and water, acting together, besides cracking the cube badly broke off four large pieces from the three sides which were enveloped by the flame.

TABLE 8

Fire tests on marble

LOC. NO.	LOCALITY	550° SLOW COOLING	550° FAST COOLING	850° SLOW COOLING	850° FAST COOLING	FLAME TEST	FLAME AND WATER TEST
35	Gouverneur, St Lawrence co.	22 Unchanged	25 Two small grains off one corner, slight crack	24 Calcined, corners rounded by flaking off of quicklime, one bad crack around three sides	23 Calcined, corners slightly rounded, not so bad as 24	183 Slight calcination at edge, some grains off, quite badly cracked	155 Slight calcination at edge, badly cracked, large pieces off

SUMMARY

From the details above given some generalizations can be drawn which are of interest and of value. It is difficult, however, to group the different kinds of stone in any order, for they vary among themselves and also act differently under different conditions. A stone which under some conditions stands up very well, will disintegrate under other conditions. Thus, for example, the granite from Northville [pl. 17] acted very badly on fast cooling after having been heated to 850°, yet, under the combined action of the flame and water, it was little damaged. Additional variations of this character are brought out by a close study of the tables of fire tests, all of which goes to show that, for one temperature, the order of resistance will differ from the order given for another temperature.

At 550°C. (1022°F.) most of the stones stood up very well. The temperature does not seem to have been high enough to cause much rupturing of the samples, either upon slow or fast cooling. The sandstones, limestones, marble and gneiss were slightly injured, while the granites seem to have suffered the least.

The temperature of a severe conflagration would probably be higher than 550°C. but there would be buildings outside of the direct action of the fire which might not be subjected to this degree of heat and in this zone the stones would suffer little injury. The sandstones might crack somewhat; but, as the cracking seems to be almost entirely along the bed, the stability of the structure would not be endangered, provided the stone had been properly set.

The gneiss would fail badly, especially if it were coarse grained and much banded. The coarse grained granites might suffer to some extent. These, though cracked to a less extent than the sandstones, would suffer more damage and possibly disintegrate if the heat were long continued because the irregular cracks, intensified by the crushing and shearing forces on the stone incident to its position in the structure, would tend to break it down. The limestones and marble would be little injured.

The temperature of 850°C. (1562°F.) represents fairly the probable degree of heat reached in a conflagration, though undoubtedly it exceeds that in some cases. At this temperature we find that the stones behave somewhat differently than at the lower temperature. All the cubes tested were injured to some degree, but among themselves they vary widely in the extent of the damage.

All the igneous stones and the gneiss at 850°C. suffered injury in varying degrees and in various ways. The coarse grained granites

were damaged the most by cracking very irregularly around the individual mineral constituents [pl. 11, Peekskill; 15, Grindstone island; and 17, Northville]. Naturally, such cracking of the stone in a building might cause the walls to crumble. The cracking is due, possibly, to the coarseness of texture and the differences in coefficiency of expansion of the various mineral constituents. Some minerals expand more than others and the strains occasioned thereby will tend to rupture the stone more than if the mineral composition is simpler. This rupturing will be greater, too, if the rock be coarser in texture. For example, a granite containing much plagioclase would be more apt to break into pieces than one with little plagioclase for the reason that this mineral expands in one direction and contracts in another, and this would set up stresses of greater proportion than would be occasioned in a stone containing little of this mineral. The fine grained-samples [pl. 12, Nyack; and pl. 14, Grindstone island] showed a tendency to spall off at the corners. The gneiss [pl. 16, Little Falls] was badly injured. In the gneisses the injury seems to be controlled by the same factors as in the granites, but there comes in here the added factor of banding. Those which are made up of many bands would be damaged more severely than those in which the banding is slight.

All the sandstones which were tested are fine grained and rather compact. All suffered some injury, though, in most cases, the cracking was along the lamination planes. In some cubes, however, transverse cracks were also developed.

The variety of samples was not great enough to warrant any conclusive evidence toward a determination of the controlling factors. It would seem, however, that the more compact and hard the stone is the better will it resist extreme heat. The following relation of the percentage of absorption to the effect of the heat is interesting. In a general way the greater the absorption, the greater the effect of the heat. A very porous sandstone will be reduced to sand and a stone in which the cement is largely limonite or clay will suffer more than one held together by silica or lime carbonate.

PERCENTAGE OF ABSORPTION	PLATE	LOCALITY
3.084	25	Warsaw
2.310	22	Potsdam
1.876	24	Medina
1.118	23	Oxford

The limestones, up to the point where calcination begins (600°–800°C.) were little injured, but above that point they failed badly, owing to the crumbling caused by the flaking of the quicklime. The purer the stone, the more will it crumble [compare pl. 24, Palatine Bridge, with pl. 22, Sandy Hill, or pl. 23, Little Falls]. The marble behaves similarly to the limestone; but, because of the coarseness of the texture, also cracks considerably. As has been mentioned before, both the limestones and marble on sudden cooling seem to flake off less than on slow cooling.

The flame tests can not be considered as indicative of the probable effect of a conflagration upon the general body of the stone in a building, but rather as an indication of the effect upon projecting cornices, lintels, pillars, carving and all thin edges of stonework. All the stones were damaged to some extent. The samples from Keeseville [pl. 13] and Northville [pl. 17] stood up very well; the limestones were, as a whole, comparatively little injured, while the marble was badly damaged. The tendency seems to be for the stone to split off in shells around the point where the greatest heat strikes the stone. The temperature of the flame probably did not exceed 700°C., so it is safe to say that in a conflagration all carved stone and thin edges would suffer. However, outside of the intense heat, the limestones would act best, while the other stones would be affected in the order: sandstone, granite, gneiss and marble.

After having been heated to 850°C., most of the stones, as observed by Buckley[1], emit a characteristic ring when struck with metal and when scratched emit a sound similar to that of a soft burned brick. It will be noted that in those stones in which iron is present in a ferrous condition the color was changed to a brownish tinge owing to the change of the iron to a ferric state. If the temperature does not exceed 550°C., all the stones will stand up very well, but at the temperature which is probable in a conflagration, in a general way, the finer grained and more compact the stone and the simpler in mineralogic composition the better will it resist the effect of the extreme heat. The order, then, of the refractoriness of the New York stones which were tested might be placed as sandstone, fine grained granite, limestone, coarse grained granite, gneiss and marble.

[1] Mo. Bur. Geol. and Mines. Ser. 2, 1904, 2:50.

PETROGRAPHIC DESCRIPTION OF STONES TESTED

1 Granite

Pine Island, Orange co. N. Y.

EMPIRE STATE GRANITE CO.

See plate 9

This is a coarse grained gneissic granite of a pinkish color due to an excess of pink feldspar in the stone. Quartz of a transparent variety is next in abundance, while biotite is present in small amounts and in places shows alteration to chlorite. Green hornblende was also noted in the hand specimen. The stone is used largely for building purposes and the smaller pieces are cut into paving blocks.

Under the microscope the feldspars were seen to be the most prominent mineral. Microcline is the chief variety with some microperthite, orthoclase and a little soda plagioclase. All are comparatively fresh. The quartz shows many fractures. Strongly pleochroic green to brown hornblende, which in places has altered to chlorite and epidote, is also present. The biotite has a slight greenish tinge probably due to chloritization. Ilmenite is not rare and large well wedge-shaped crystals of sphene were also seen. Some zircons, small apatites and pyrite grains are scattered through the mass.

Pressure phenomena are well shown, evidenced by the crushing of the quartz, bending of the mica scales and fracturing of the feldspar. In some of these cracks muscovite and calcite are present. The crystals of the stone are well interlocked, giving a firmness and compactness to the whole mass.

2 Granite

Garrison, Putnam co. N. Y.

KING GRANITE CO.

See plate 10

This is a fine grained gray granite used for building purposes, which, in the hand specimen, shows light feldspar, smoky quartz and biotite, with subordinate grains of garnet.

In the thin section, the feldspars, which are quite fresh, were seen to be orthoclase, microcline and microcline microperthite, microperthite and a soda plagioclase. Deep brown to light biotite is present, and has bleached in places, but in others has altered to chlorite. There are also small amounts of secondary calcite,

apatites and some recrystallized quartz. A few ore grains are scattered through the mass. This granite also shows evidences of crushing.

3 Granite

Peekskill, Westchester co. N. Y.

COLEMAN, BRUCHARD & COLEMAN

See plate 11

The stone from this locality has been quarried for use in the construction of the Croton dam. It is a medium to coarse grained, very light stone made up of white feldspar, smoky quartz and muscovite with small amounts of biotite.

Under the microscope, quartz and feldspar are the more prominent minerals, the feldspar being mostly a very acid plagioclase idiomorphic with respect to the orthoclase, of which there is comparatively little. Some microline and micropegmatite are also present. The feldspars show alteration, mostly to muscovite. They are clouded, usually in the center, although, in some cases, the alteration has been in zones around the outside of the crystals, beyond which more feldspar has been deposited. Of the alteration products muscovite alone is recognizable, though kaolinite may also be present. Both muscovite and biotite were seen, the former being the more abundant and the latter showing alteration to epidote in places. Chlorite is an accessory mineral, and apatite crystals are not rare.

4 Diabase

Nyack, Rockland co. N. Y.

MANHATTAN TRAP ROCK CO.

See plate 12

This is a fine grained rock of a dark gray color used entirely for road metal and concrete. It is so fine grained that the mineral species can not be easily distinguished with the naked eye, but bright cleavage faces suggest the presence of a plagioclase feldspar.

Under the microscope the plagioclase was the only feldspar recognized. It is very basic, in part probably bytownite and it occurs in lath shaped crystals having an average length of .5 millimeter and an average width of .10 millimeter. Colorless to green augite makes up the greater part of the remainder of the section. This augite, has, in places, altered to hornblende. Magentite and other metallic grains, probably ilmenite, are also present.

7 Norite

Keeseville, Essex co. N. Y.

PROPERTY OF C. B. WHITE

See plate 13

The quarry at this locality is not at present in operation, but formerly the stone was employed as a building stone. In the quarry the stone is seen to vary considerably in texture and mineral composition. The samples which were tested are greenish in color, rather medium to fine grained and composed of green feldspar, some biotite and some form of pyroxene. A few small garnets were also noted in the hand specimen.

No thin section was cut from this rock.

9 Granite

Grindstone island, Jefferson co. N. Y.

PARRY BROS.

See plate 14

This is a fine grained red granite which from this particular quarry has been used only for paving blocks, although from other quarries on the island it has been employed as a building and monumental stone. The red color is due to an excess of pink feldspar. Light and smoky quartz are easily distinguished as are also little scales of biotite.

In thin section the feldspars were seen to be chiefly microcline with some orthoclase and an acid plagioclase. They are both cloudy and clear; the orthoclase seems to have suffered the most from alteration while the microcline remained fresh. Much quartz is present. Both muscovite and biotite are represented, and around some of the biotite scales chlorite and epidote occur as alteration products. Some apatite crystals, magnetite, hematite and other ore grains are present in small amounts.

10 Granite

Grindstone island, Jefferson co. N. Y.

KELLY & PACKARD

See plate 15

This is a coarse grained red granite which is used as a building and monumental stone. The color is due to an excess of pink feldspar, some of the crystals of which reach $\frac{1}{2}$ inch in size.

Light quartz and biotite make up the rest of the rock, with the exception of a few pyrite grains. The biotite seems to be associated with an alteration mineral which is probably chlorite.

This stone, in the thin section, shows evidences of crushing, for the quartz is considerably cracked and the feldspar, which is mostly microcline with some microperthite, is also much cracked. Micropegmatite was also noted and the feldspars show kaolinization to some extent. Much titanite, biotite, chlorite, ilmenite, pyrite and magnetite seem to be grouped together in large areas. All of these may be alteration products from a brown titanium-bearing hornblende. A few zircons and apatites were also seen in the section.

11 Gneiss

Little Falls, Herkimer co. N. Y.

HALLIMAN BROS.

See plate 16

This is an augen gneiss which is being used for road metal and has been used, to some extent, in the construction of local buildings. The color is prevailingly greenish gray, though, in places, it is rather pinkish. The feldspar eyes are well defined in some places. The texture, as a whole, is rather fine.

The microscope showed that the eyes are made up of microperthite around which is a fine grained matrix of quartz and feldspar which has weathered to mica in some places. Through these large crystals of microperthite are stringers of quartz and feldspar. Green hornblende, apatites and magnetite grains were also noted in the section.

14 Granite

Northville, Fulton co. N.Y.

NORTHVILLE GRANITE & MARBLE CO.

See plate 17

This garnetiferous gneissic granite has been quarried only on a small scale for local monuments. The color is quite dark due to the large amount of hornblende in the rock. It is rather coarse grained, though variable in texture. Green feldspar and light quartz are easily recognized and there are many large crystals of garnet, some of them reaching a size of over $\frac{1}{2}$ inch.

In the thin section the feldspar was seen to be largely a soda plagioclase, with some orthoclase which had altered in places to

mica. The quartz showed evidences of crushing. Hornblende, biotite which has altered to chlorite in places, pyrite grains, zircons and apatites were also noted and large crystals of red garnet are common in the section.

8 Sandstone

Potsdam, St Lawrence co. N.Y.

POTSDAM RED SANDSTONE CO.

See plate 18

This is a quartzitic red sandstone, compact and even grained. The color varies somewhat and the bedding planes are quite prominent. It is extensively used as a building stone.

Under the microscope the grains appear to be well rounded; many have become enlarged by a secondary growth of silica and the original form of the grain is shown by a rim of limonite. The stone is well cemented and in some cases the grains show complicated interlocking. With the exception of a few scales of muscovite and some grains of magnetite, the section is made up entirely of quartz grains which rarely exceed .5 millimeter in diameter.

16 Sandstone

Oxford, Chenango co. N.Y.

F. G. CLARKE BLUESTONE CO.

See plate 19

The stone from this locality, which is used extensively as a building stone, is fine grained and of a bluish gray color.

In the thin section the rock was seen to be composed of angular to rounded grains of quartz and feldspar, which in places has weathered to mica. The cementing material is mostly silica, though there is some calcite and some limonite. The texture is quite fine, the average size of the grains being .10 millimeter. A few mica scales and pyrite grains were also noted in the section.

17 Sandstone

Medina, Orleans co. N.Y.

CARSON BROS.

See plate 20

This is a fine grained red sandstone which is quite uniform in texture and compact. It is widely used as a building stone.

The microscope shows that the grains, which are mostly quartz, are well rounded and encased in limonite. Some of them have become enlarged by secondary growth, thus making the stone compact and firm. Weathered feldspar and plagioclase make up a large part of the section. Some ore grains, probably magnetite and pyrite, are scattered through the mass. The texture is quite even, the grains averaging .30 millimeter in diameter.

19 Sandstone

Warsaw, Wyoming co. N.Y.

WARSAW BLUESTONE CO.

See plate 21

This sandstone, used for building purposes, has a bluish gray color, is rather loose and of a fine grain and even texture.

The rock is made up mostly of very fine subangular grains of quartz and weathered feldspar cemented together by calcite. Biotite and muscovite scales, chlorite, recrystallized quartz, some ilmenite and other ore grains were also noted in the section.

5 Limestone

Sandy Hill, Washington co. N.Y.

HIGLEY & BARBER

See plate 22

The stone from this locality is fine grained and bluish gray and is used mostly for building purposes. It is quite hard and compact and the texture, as a whole, is fairly even, though it varies somewhat to a coarser grain.

The microscope revealed more or less angular crystals of calcite cemented firmly by a fine grained cloudy calcareous material. Some rounded quartz grains and a few pyrite grains were also noted in the section.

12 Limestone

Little Falls, Herkimer co. N.Y.

P. KEARNEY

See plate 23

The stone from this quarry, which is used locally as a building stone, is light gray in color, fairly compact and, as a whole, fine grained. It is made up of dolomite rather than calcite.

The microscope showed it to be composed of good crystals of

dolomite in a cement of fine grained calcareous material and limonite. Rounded quartz grains are scattered through the section, thus giving the rock a silicious character.

13 Limestone

Palatine Bridge, Montgomery co. N.Y.

MOHAWK STONE CO.

See plate 24

This limestone has been used for building purposes, but at present it is being quarried for railroad ballast. It is grayish blue in color, quite compact and hard. For the most part it is quite fine in texture, though it varies to a coarser grain.

In the thin section were seen good calcite crystals, some small grains of quartz and a few pieces of plagioclase changing to calcite, all in a fine grained material which is probably calcite mixed with more or less clay. A few magnetite grains were also seen in the section.

15 Limestone

Amsterdam, Montgomery co. N.Y.

D. C. HEWITT

See plate 25

The stone from this locality is extremely variable. The good stone, employed for building purposes, is dark gray, fine grained and fairly even in texture. However, in it are coarser layers. The poorer stone is rather black, loose, earthy and coarse. This is used for road metal.

The thin section shows the stone to be made up largely of calcite crystals in a fine cloudy material which is probably a calcareous material mixed with some clay. Some angular quartz grains and a few plagioclase grains changing to calcite were also noted. The texture is variable and there are some pore spaces. A few ore grains are scattered through the mass.

35 Marble

Gouverneur, St Lawrence co. N.Y.

ST LAWRENCE MARBLE CO.

See plate 26

This is a fairly coarse grained stone of a bluish color, varying to a lighter tint, used extensively for building and decorative pur-

poses. There seem to be planes of weakness in the stone due to a slight variation of the texture.

No thin section was cut from this sample.

REFERENCES

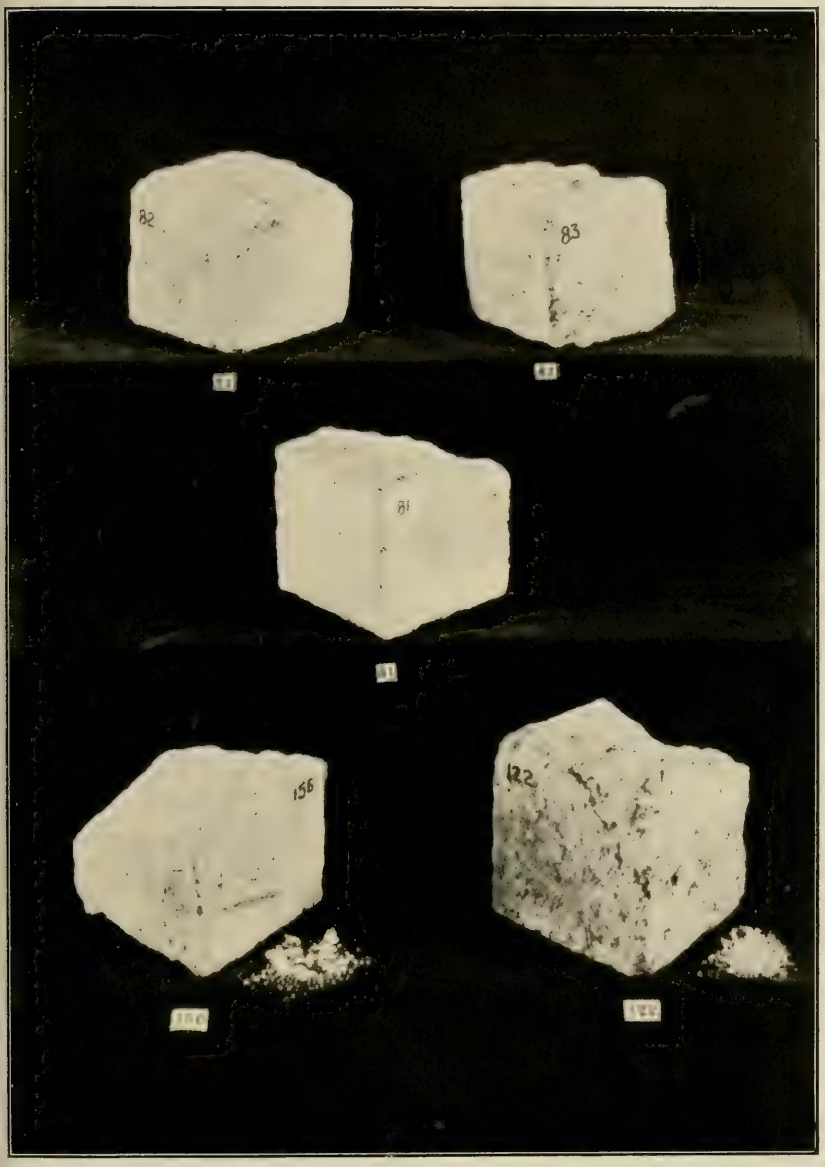
Previous investigations of refractoriness of building stones

Buckley. Wis. Geol. and Nat. Hist. Sur. Bull. 1898. 4:73, 385.
—— Mo. Bur. Geol. and Mines. Ser. 2. 1904. 2:50.
Cutting. Weekly Underwriter. 1880. 22:257, 287, 304; 23:42.
Merrill, G. P. Stones for Building and Decoration. N.Y. 1903. p. 424.
Van Schwartz. Fire and Explosion Risks, a Handbook etc. N.Y. 1904.

Effect of fire on stone as observed in conflagrations

Anon. Building News and Eng. Jour. 1904. 87:2.
Anon. Engineering News. 1904. 51:173.
Grieshaber. Engineering News. 1904. 51:173.
Woolson. Engineering News. 1904. 51:95, 173.

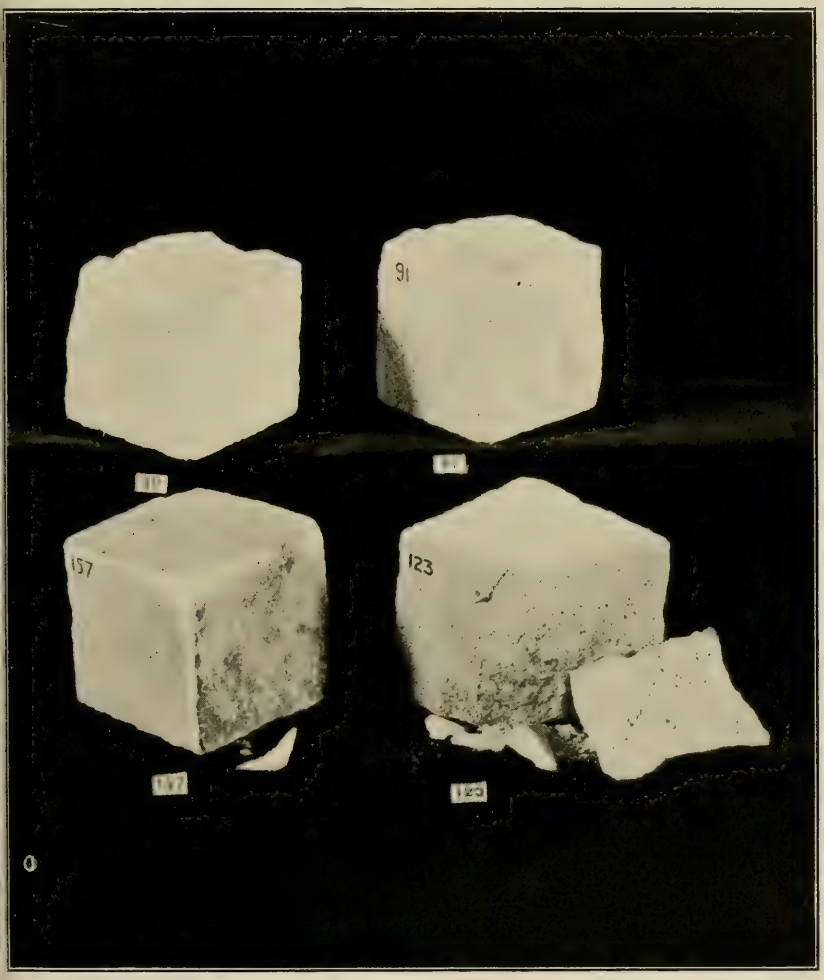
Plate 9



1 Granite
Pine Island, Orange co. N. Y.

82 550° slow cooling
83 550° fast cooling
81 850° slow cooling
156 Flame test
122 Flame and water test

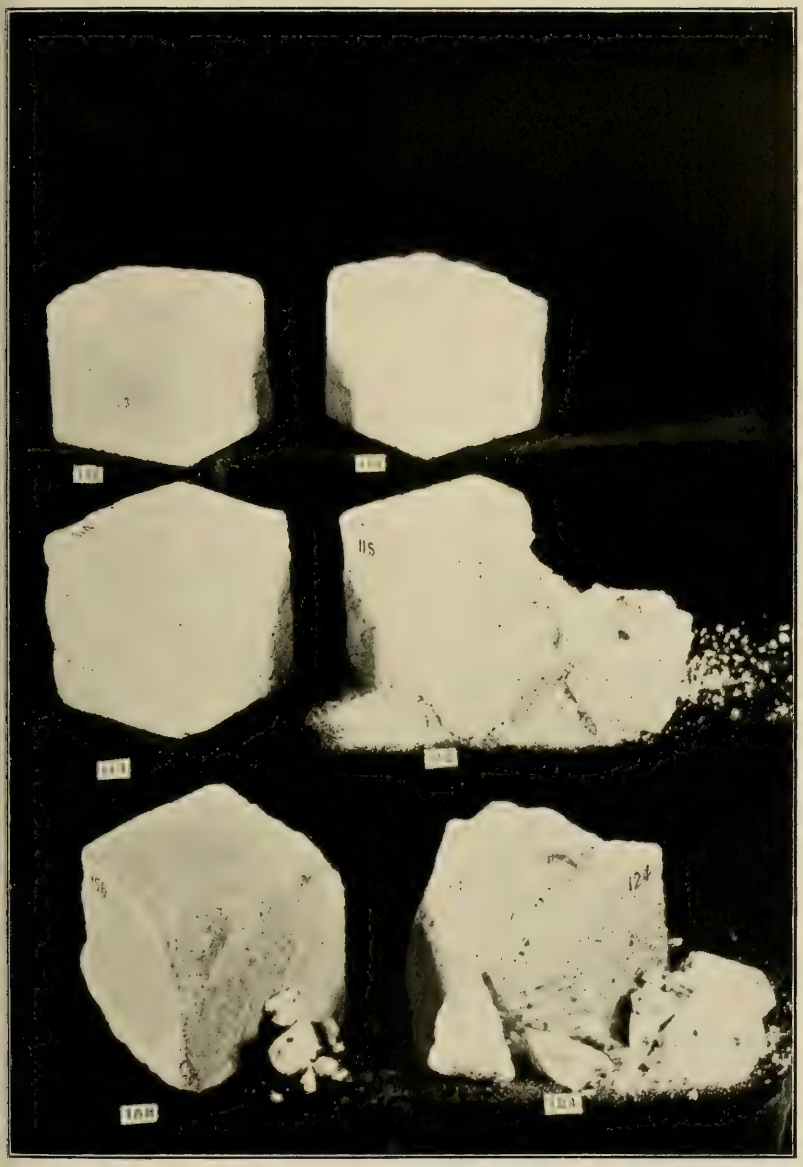
Plate 10



2 Granite
Garrison, Putnam co. N. Y.

90 550° slow cooling
91 550° fast cooling
157 Flame test
123 Flame and water test

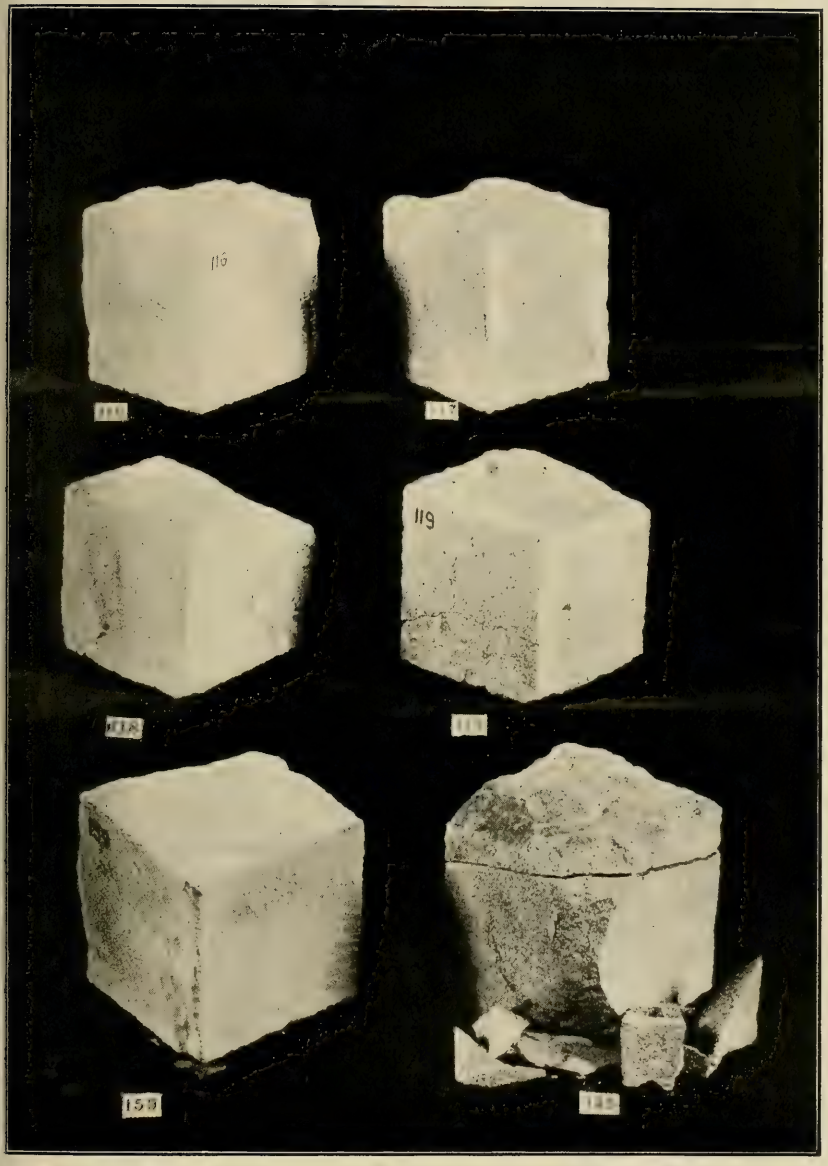
Plate 11



3 Granite
Peekskill, Westchester co. N. Y.

112 550° slow cooling
113 550° fast cooling
114 850° slow cooling
115 850° fast cooling
158 Flame test
124 Flame and water test

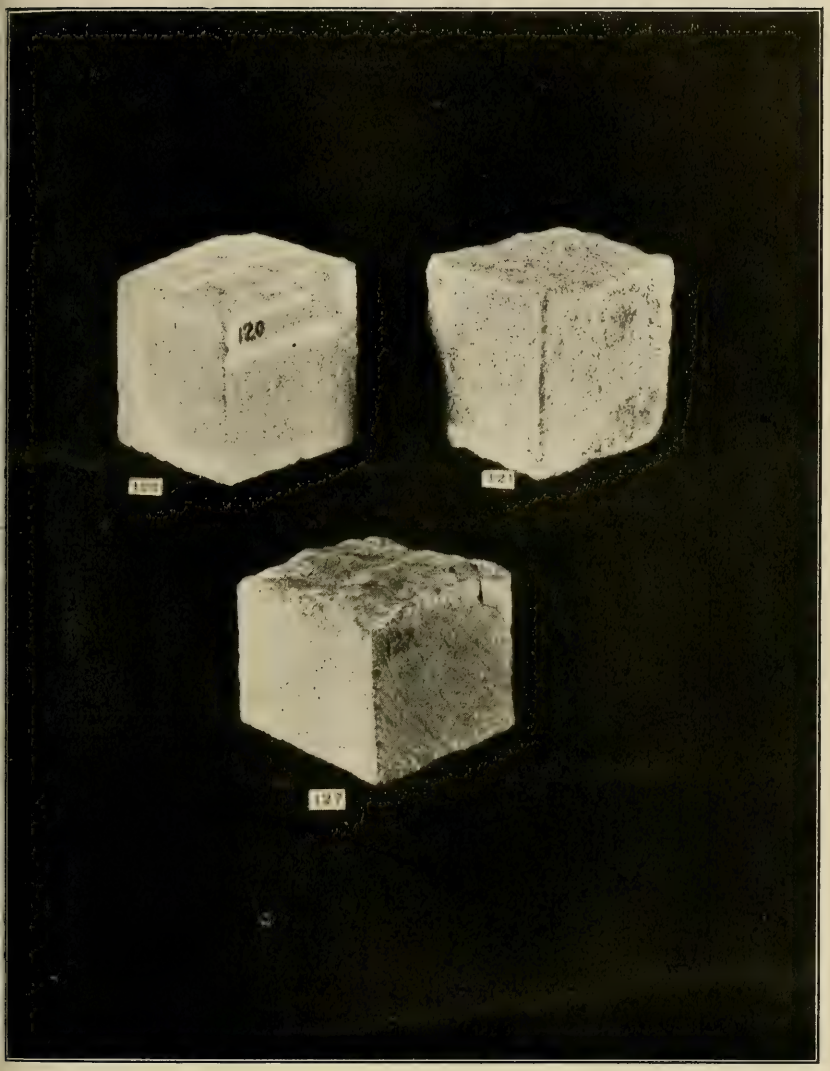
Plate 12



4 Diabase
Nyack, Rockland co. N. Y.

116	550° slow cooling	117	550° fast cooling
118	850° slow cooling	119	850° fast cooling
159	Flame test	125	Flame and water test

Plate 13



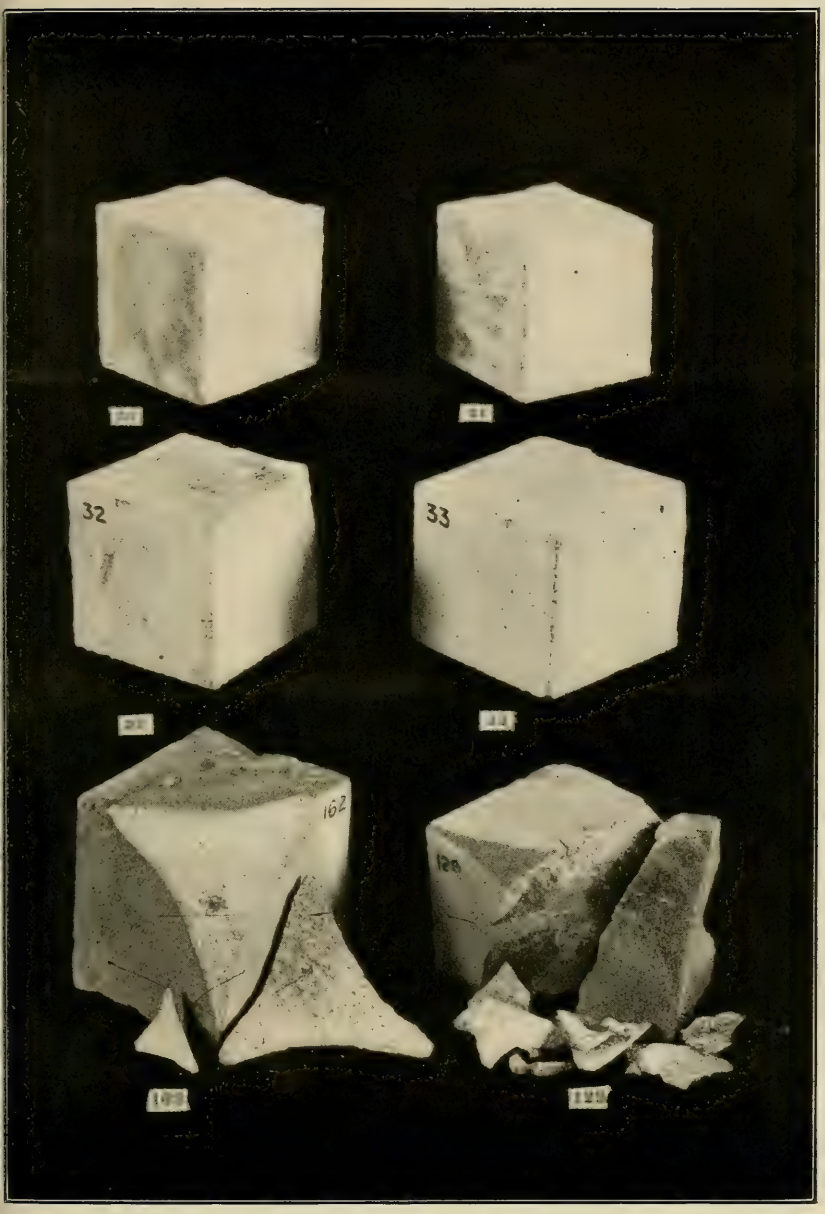
7 Norite

Keeseville, Essex co. N. Y.

120 550° slow cooling 121 550° fast cooling

127 Flame and water test

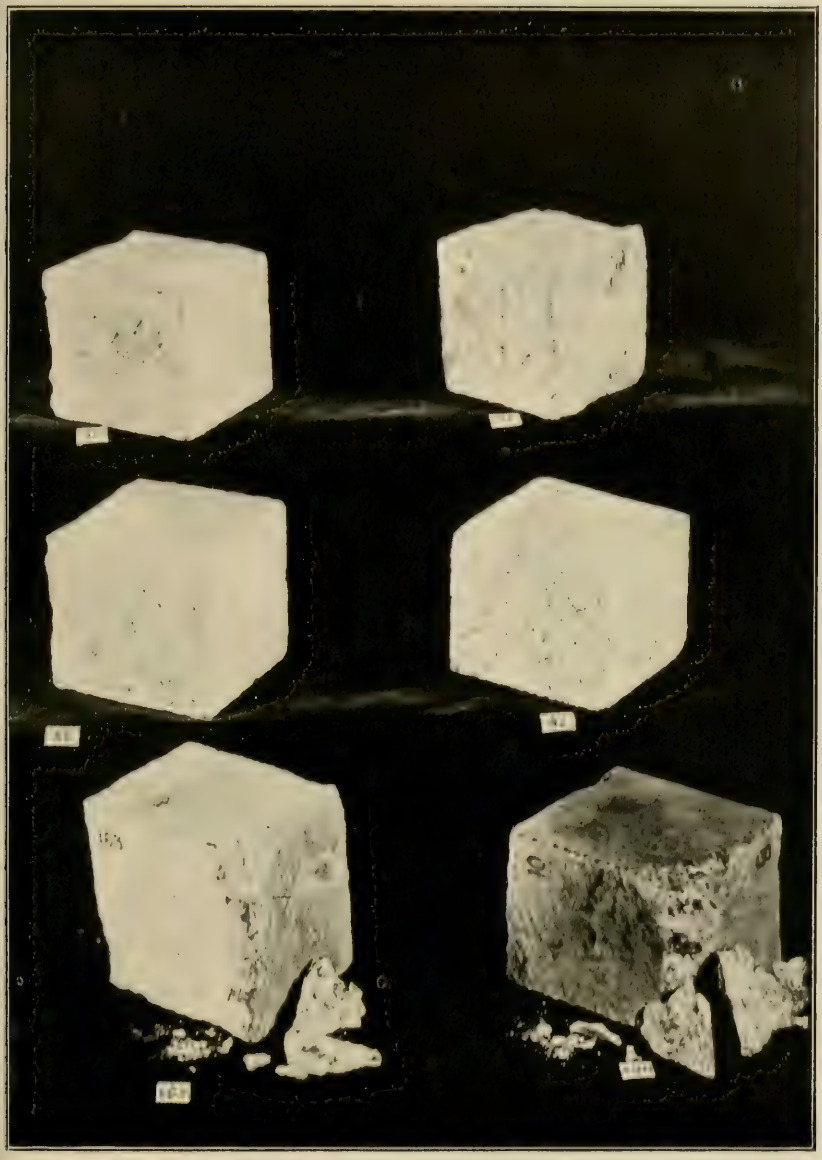
Plate 14



9 Granite
Grindstone island, Jefferson co. N. Y.

30 550° slow cooling
31 550° fast cooling
32 850° slow cooling
33 850° fast cooling
162 Flame test
129 Flame and water test

Plate 15

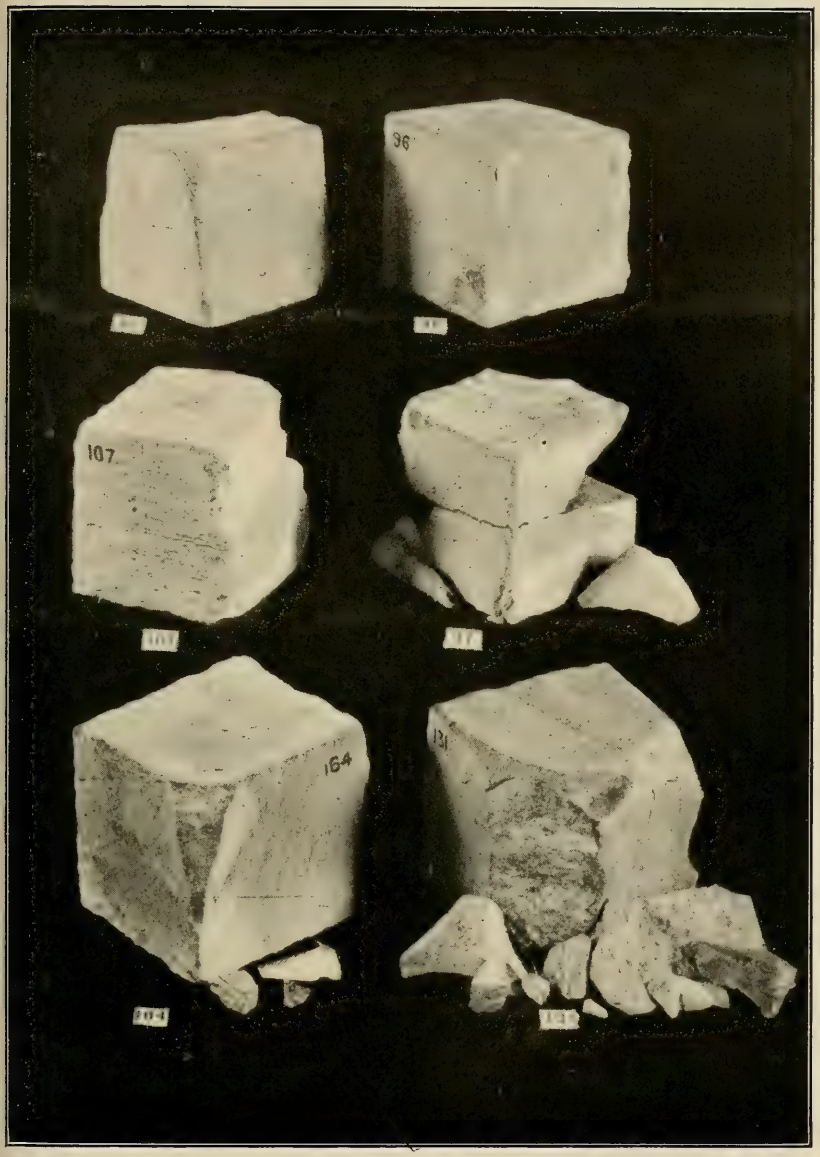


10 Granite

Grindstone island, Jefferson co. N. Y.

43	550° slow cooling	44	550° fast cooling
45	850° slow cooling	42	850° fast cooling
163	Flame test	130	Flame and water test

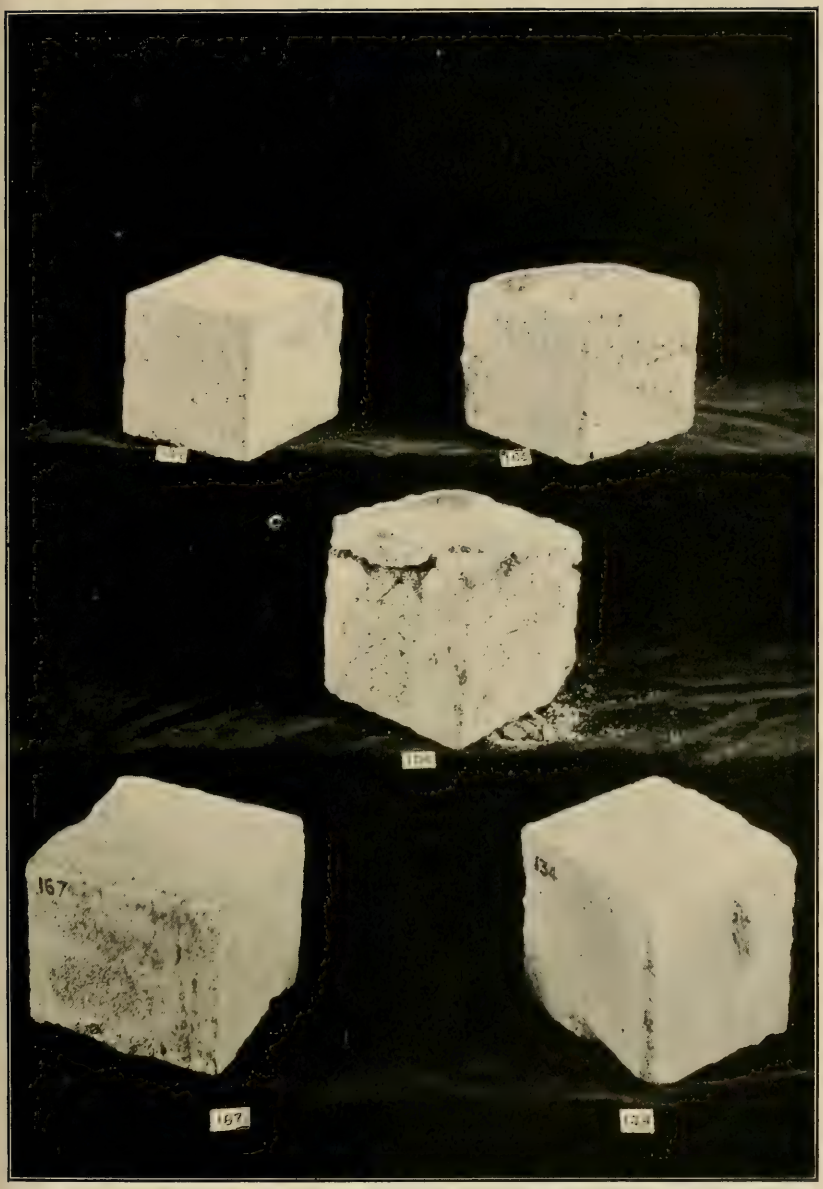
Plate 16



11 Gneiss
Little Falls, Herkimer co. N. Y.

95	550° slow cooling	96	550° fast cooling
107	850° slow cooling	97	850° fast cooling
164	Flame test	131	Flame and water test

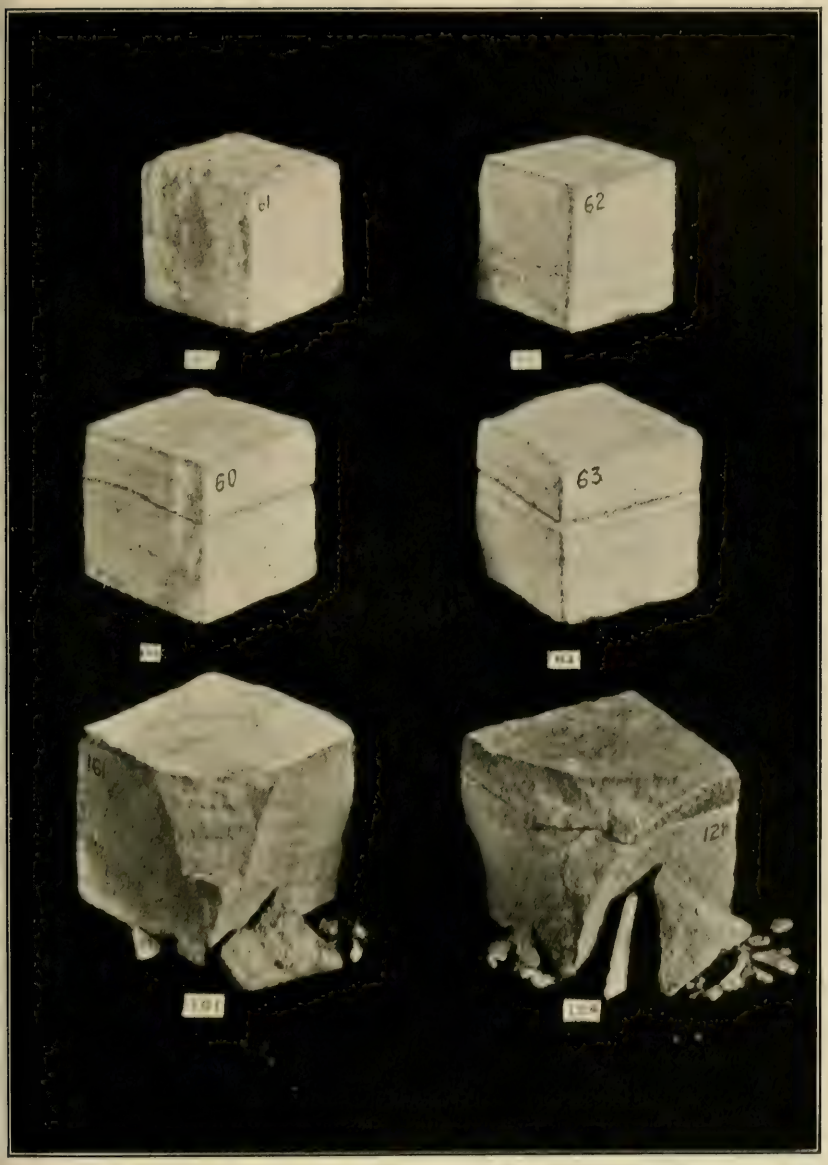
Plate 17



14 Granite
Northville, Fulton co. N. Y.

104 550° slow cooling
105 550° fast cooling
106 850° fast cooling
167 Flame test
134 Flame and water test

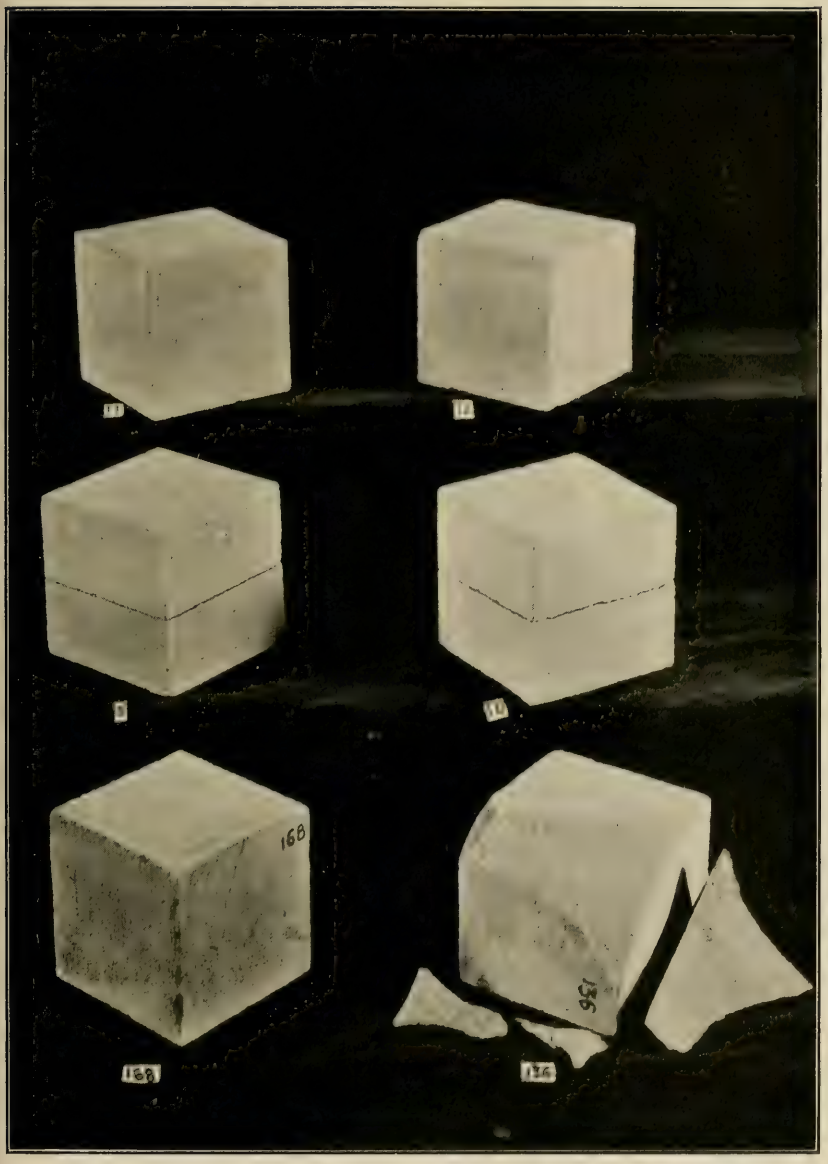
Plate 18



8 Sandstone
Potsdam, St Lawrence co. N. Y.

61	550° slow cooling	62	550° fast cooling
60	850° slow cooling	63	850° fast cooling
161	Flame test	128	Flame and water test

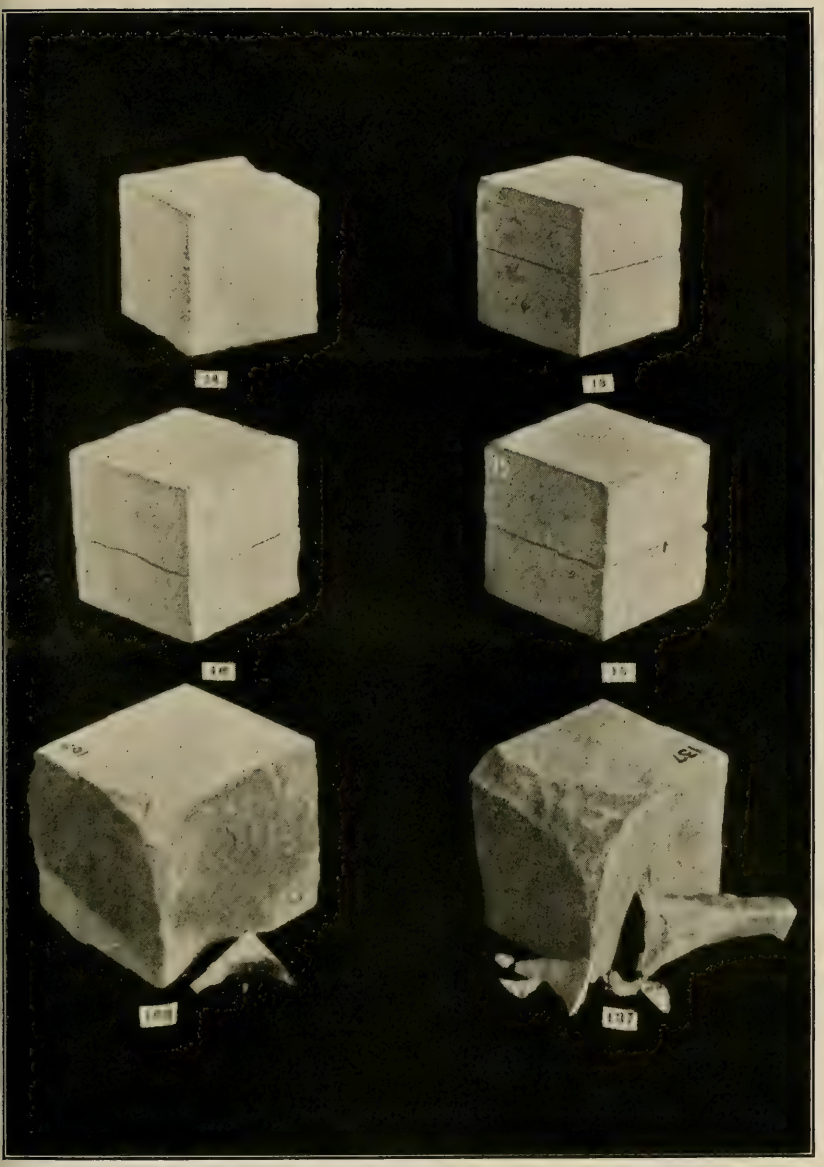
Plate 19



16 Sandstone
Oxford, Chenango co. N. Y.

11	550° slow cooling	12	550° fast cooling
9	850° slow cooling	10	850° fast cooling
168	Flame test	136	Flame and water test

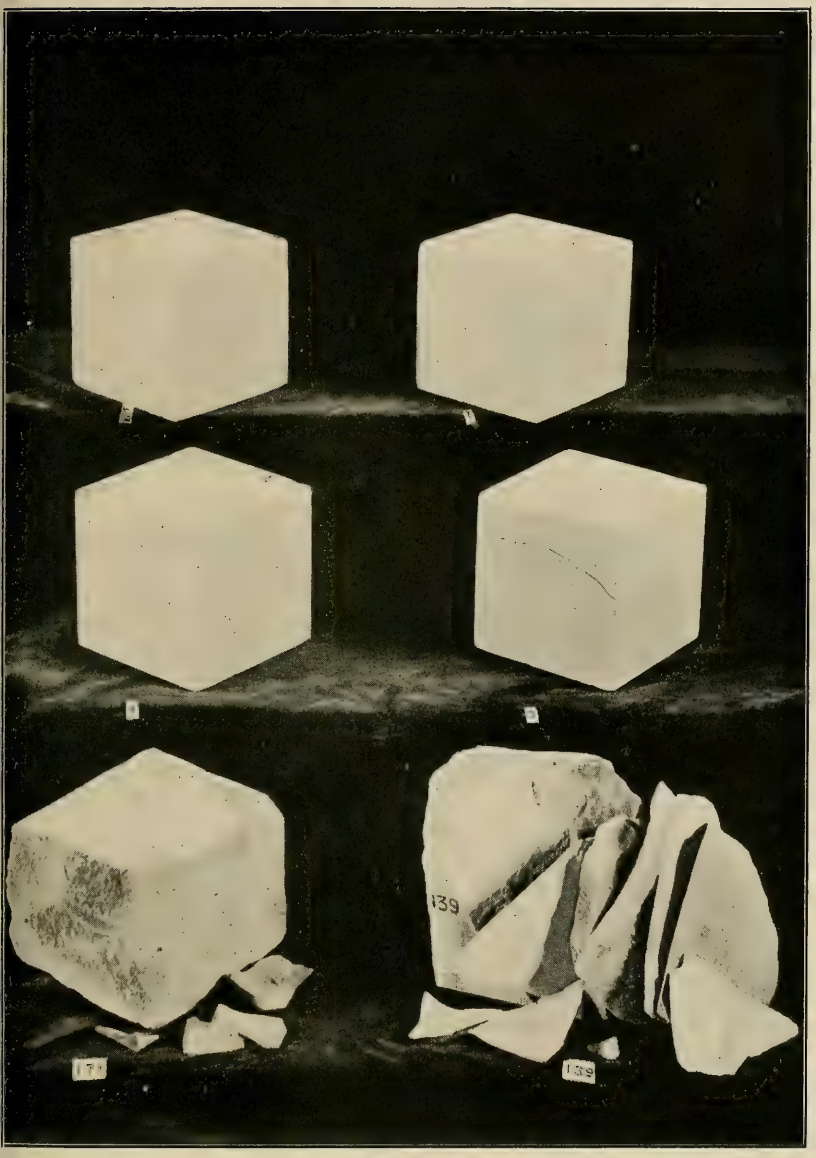
Plate 20



17 Sandstone
Medina, Orleans co. N. Y.

14	550° slow cooling	13	550° fast cooling
16	850° slow cooling	15	850° fast cooling
169	Flame test	137	Flame and water test

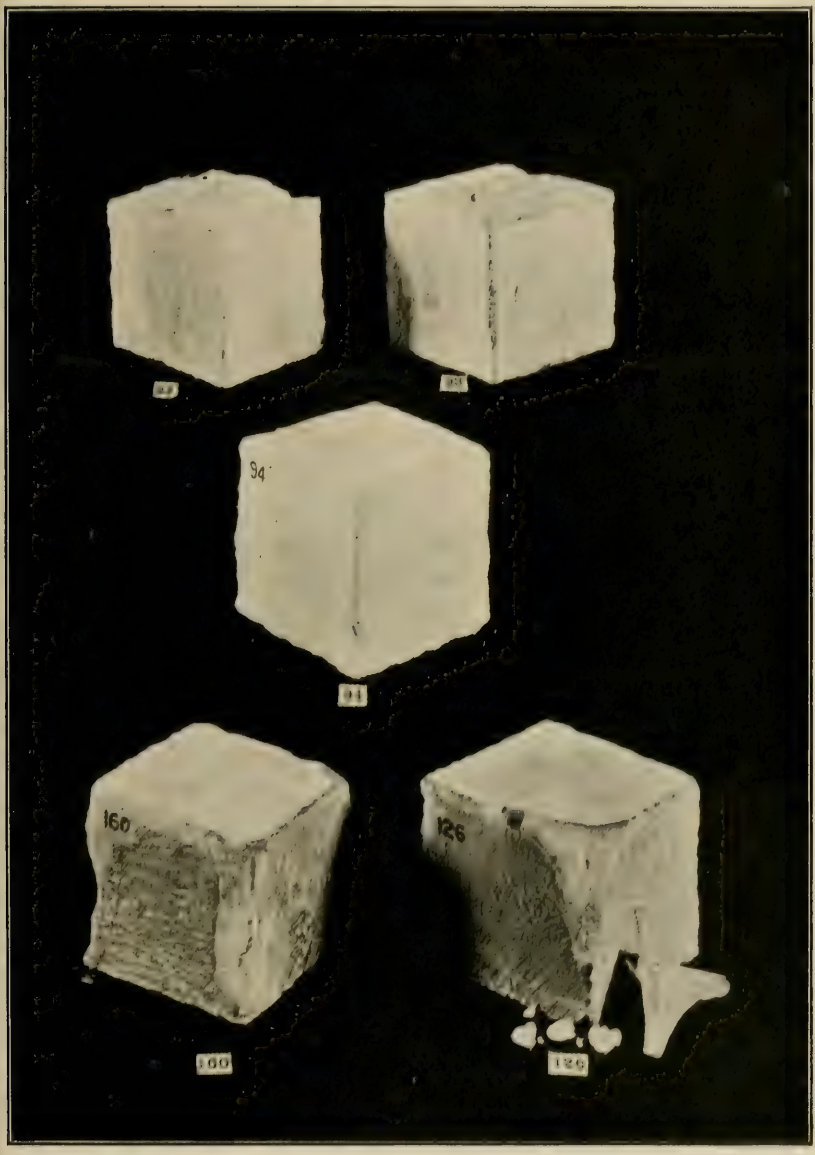
Plate 21



19 Sandstone
Warsaw, Wyoming co. N. Y.

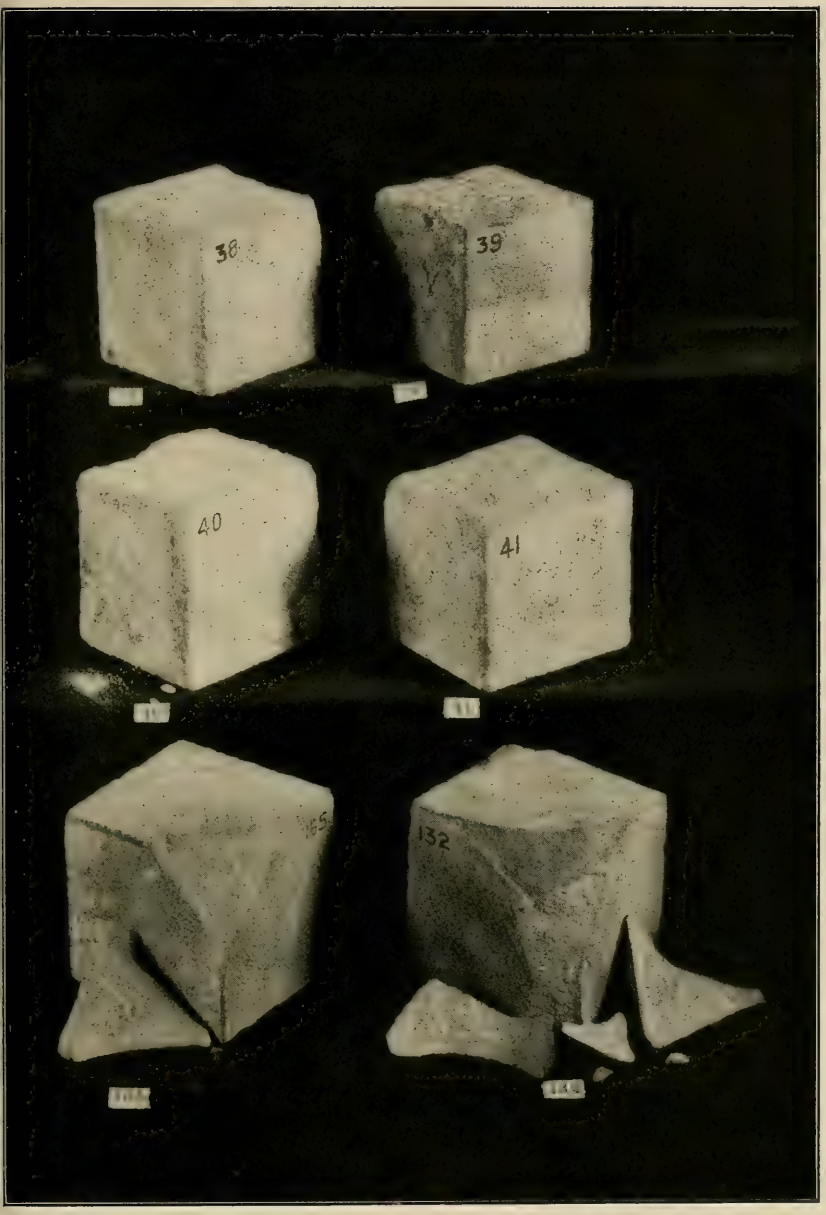
2	550° slow cooling	1	550° fast cooling
4	850° slow cooling	3	850° fast cooling
171	Flame test	139	Flame and water test

Plate 22



5 Limestone
Sandy Hill, Washington co. N. Y.

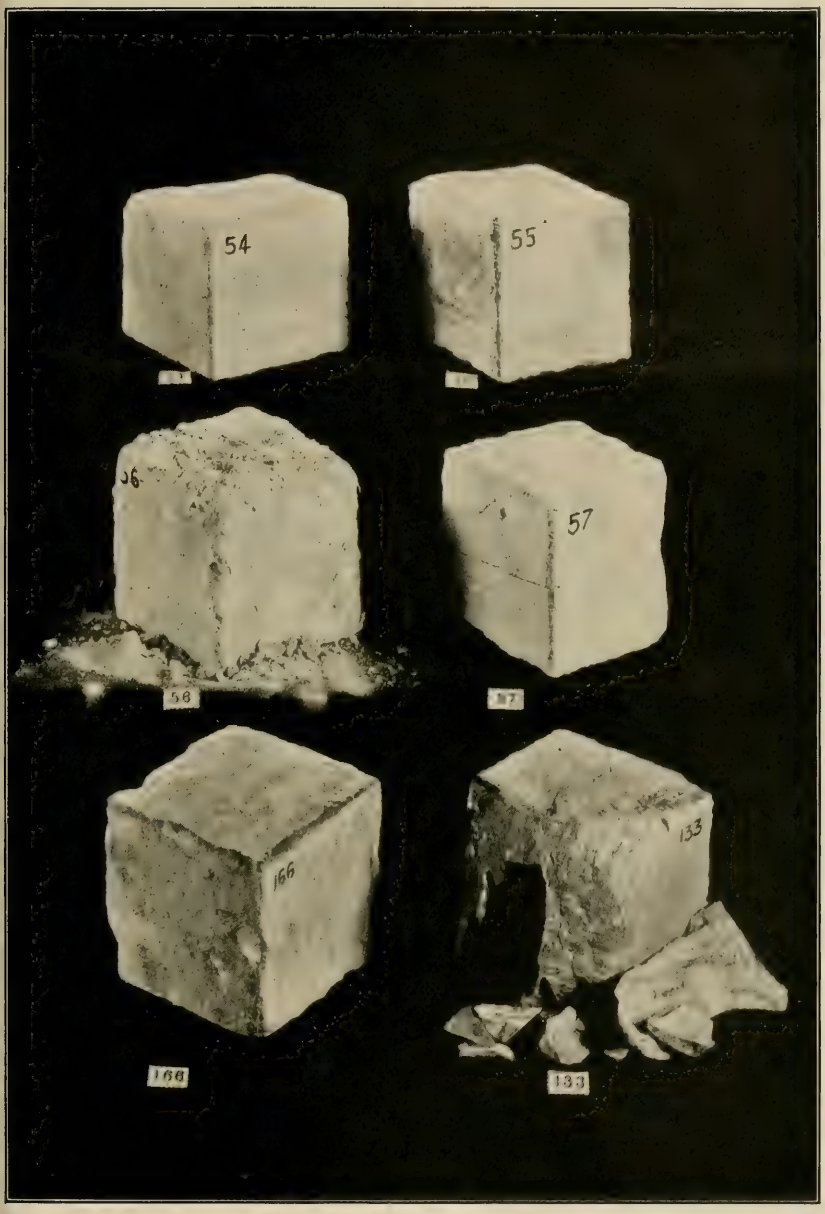
92 550° slow cooling
93 550° fast cooling
94 850° fast cooling
160 Flame test
126 Flame and water test



12 Limestone
Little Falls, Herkimer co. N. Y.

38	550° slow cooling	39	550° fast cooling
40	850° slow cooling	41	850° fast cooling
165	Flame test	132	Flame and water test

Plate 24

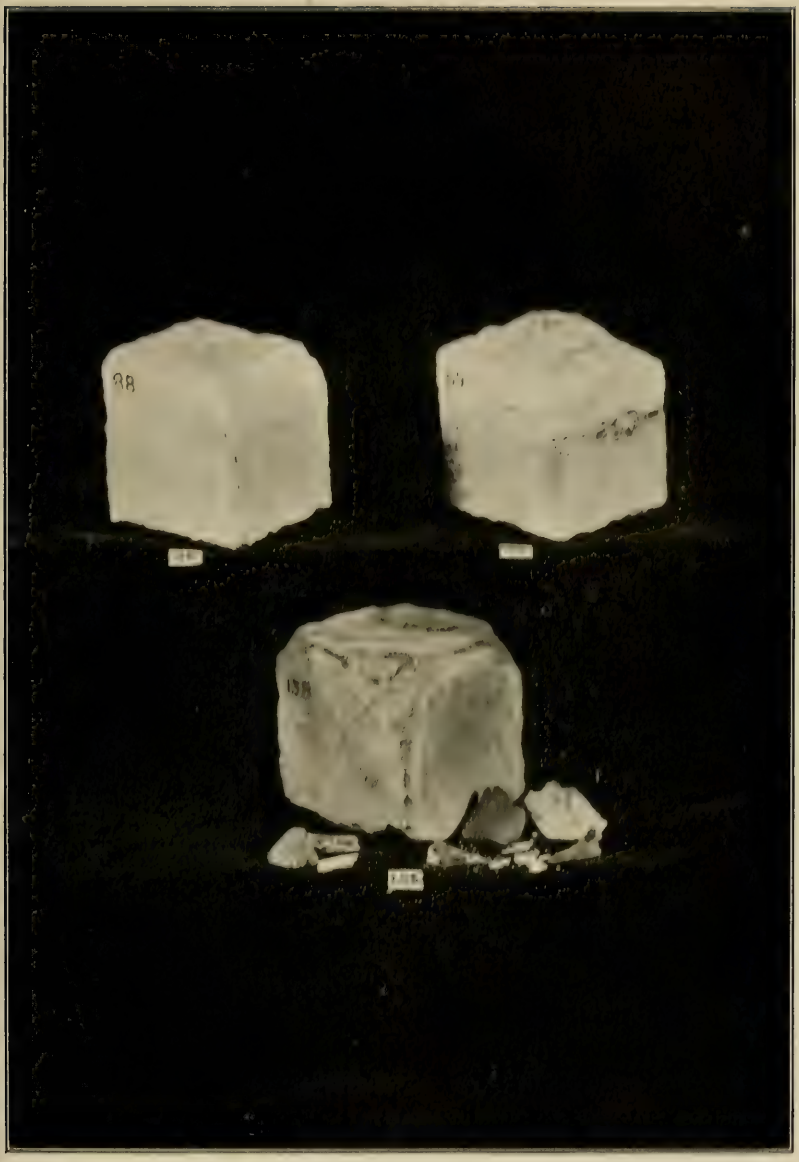


13 Limestone

Palatine Bridge, Montgomery co. N. Y.

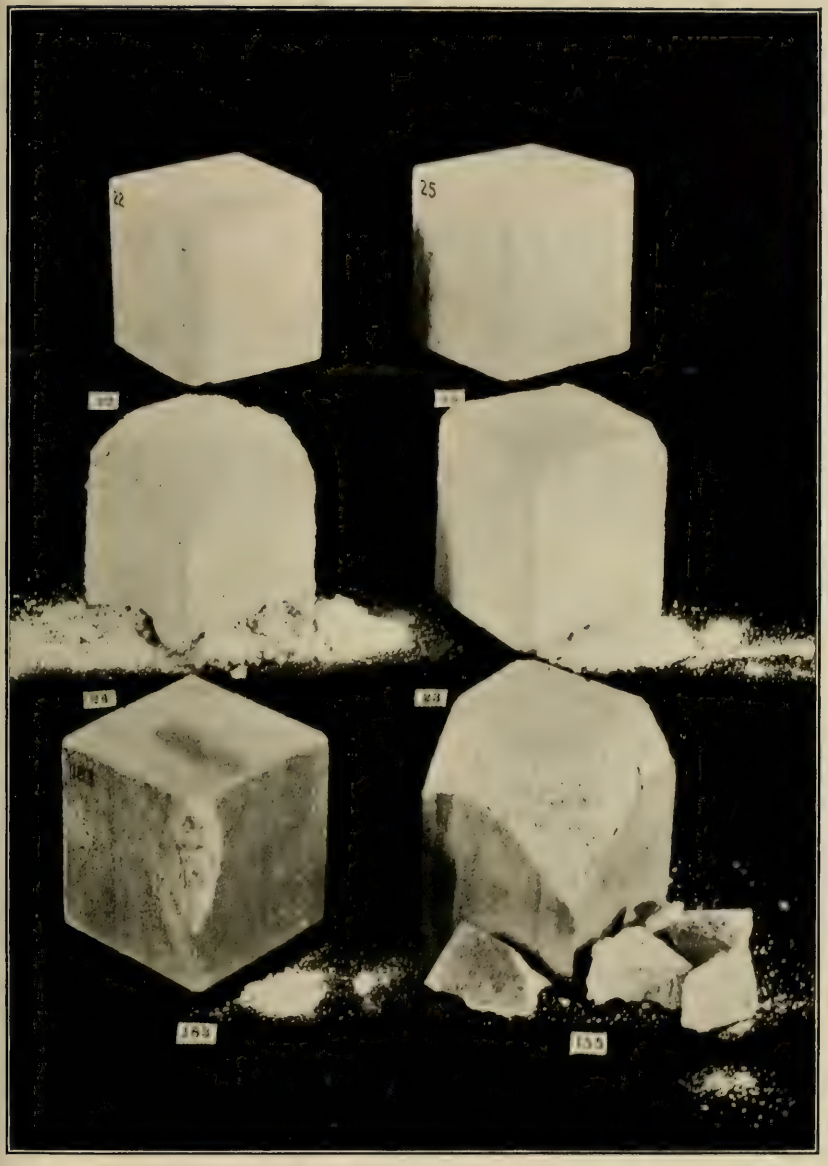
54 550° slow cooling
55 550° fast cooling
56 850° slow cooling
57 850° fast cooling
166 Flame test
133 Flame and water test

Plate 25



15 Limestone
Amsterdam, Montgomery co. N. Y.
88 550° slow cooling 89 550° fast cooling
135 Flame and water test

Plate 26



35 Marble
Gouverneur, St Lawrence co. N. Y.

22	550° slow cooling	25	550° fast cooling
24	850° slow cooling	23	850° fast cooling
183	Flame test	155	Flame and water test

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New York State Museum

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M161m–Ja6–300

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